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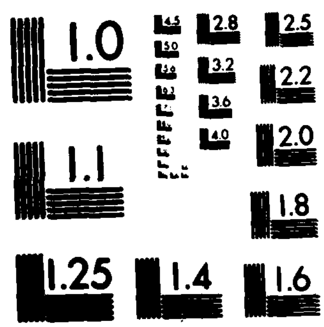

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TECHNICAL APPENDIXES
VOLUME 3

OF THE

GENERAL REEVALUATION

AND

ENVIRONMENTAL IMPACT STATEMENT

FOR

FLOOD CONTROL AND RELATED PURPOSES

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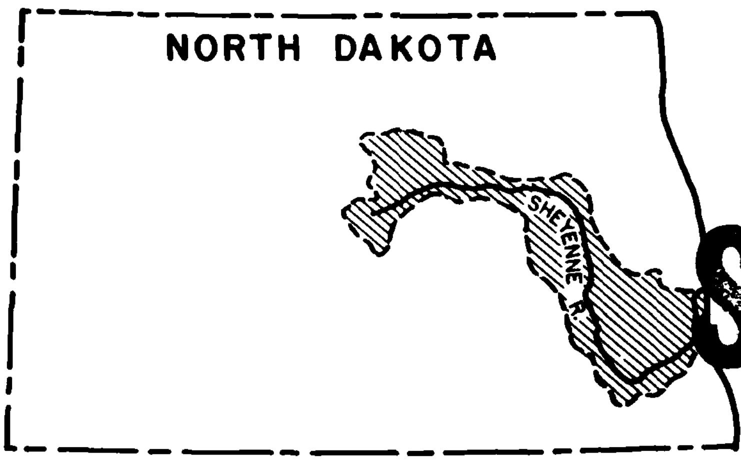

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SHEYENNE RIVER

NORTH DAKOTA

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US Army Corps of Engineers
St. Paul District

AUGUST 1982

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SHEYENNE RIVER
NORTH DAKOTA

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report addresses the water resource and related problems and needs of the lower Sheyenne River basin with particular emphasis on reducing flood damages. The main report summarizes the water resource and related problems and needs of the basin, the alternatives evaluated, the process used to develop and select a plan, conclusion and recommendations, and the environmental impact statement.

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SHEYENNE RIVER, NORTH DAKOTA

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PREFACE

The General Reevaluation and Environmental Impact Statement for flood control and related purposes in the Sheyenne River basin, North Dakota, presents the findings, conclusions, and recommendations of studies conducted from February 1976 through August 1982.

The report addresses the water resource and related problems and needs of the lower Sheyenne River basin with particular emphasis on reducing flood damages - the most significant local water resource need. The goal of the reevaluation is to identify a plan for water resource development that meets the needs of the basin, is consistent with the national objective of economic development and the national considerations for environmental quality, and is implementable.

The study completely reevaluates and reformulates work done during the feasibility study (1963 through 1968). The 1968 feasibility report recommended construction of the multiple-purpose Kindred Lake project. The Kindred Lake project would reduce flood damages, improve water quality, provide for recreation, and enhance fish and wildlife. The report also recommended that Baldhill Dam be operated to provide more flood control storage before spring runoff.

In 1970, Congress authorized the Kindred Lake project for construction. Before funds were appropriated for the reevaluation, special studies examined the effects the project would have on groundwater levels in the Sheyenne National Grassland, the potential shoreline erosion around Kindred Lake, and the effects the project would have on water quality. In 1976, following completion of these studies, the Corps received appropriations to begin the reevaluation.

Several events occurred between completion of the feasibility study (1968) and the start of the reevaluation studies (1976) that significantly cahnged planning guidwlines. These changes required a complete reevaluation of the study area. The events included:

1. Passage of the National Environmental Policy Act of 1969,

2. Completion of the special studies (1974),

3. Adoption by the Water Resources Council of new principles and standards for planning water and related land resources (1973), and

4. Uncertainty in the status of the Garrison Diversion Unit (1975 and 1976).

The principal elements of the water resource plan selected on the basis of the reevaluation and presented in this report are:

- Adoption (or continuation) and enforcement of floodplain regulations in flood-prone areas of the basin (non-Federal implementation).

- Regulation of drainage to ensure that future drainage of wetlands would not increase downstream flood damages (non-Federal implementation).

- Control of private levee construction to prevent increases in upstream and/or downstream flood damages (non-Federal implementation).

- Levees and a flood diversion channel at West Fargo/Riverside (Corps of Engineers implementation with a non-Federal sponsor).

- A flood diversion channel from Horace to West Fargo (Corps of Engineers implementation with a non-Federal sponsor).

- A 5-foot raise of Baldhill Dam to provide additional flood control storage (Corps of Engineers implementation with a non-Federal sponsor).

- Ring levees or other individualized flood proofing at flood-prone farmsteads and residences (non-Federal or other Federal agency implementation or continued evaluation for potential Corps of Engineers implementation).

- A multiple-purpose dam for flood control and recreation on Dead Colt Creek, a tributary of the Sheyenne River (non-Federal implementation).

- Increase in the storage capacity of wetlands (drained and existing) to retain floodwaters (non-Federal or other Federal agency implementation).

The General Reevaluation and Environmental Impact Statement consists of four volumes: the main report and environmental impact statement (published jointly in one volume) and three volumes of technical appendixes.

The main report summarizes the water resource and related problems and needs of the basin, the alternatives evaluated, the process used to develop and select a plan, the conclusions of the study, and the recommendations for Federal participation through the Corps of Engineers.

The environmental impact statement, bound with the main report, describes the environmental effects of implementation of the selected plan and discusses the relative merits of the other alternatives.

The technical appendixes present the detailed information used in investigating the problems and needs, assessing the impacts of the alternatives, and evaluating the alternatives and technical details of the selected plan.

These "General Reevaluation" studies were accomplished under the title of "Phase I General Design Memorandum" during the period 1976 through February 1982. Any references in these general reevaluation documents to "Phase I General Design Memorandum" is synonomus with a reference to a "general reevaluation".

Comments or inquiries on the General Reevaluation and Environmental Impact Statement should be sent to:

District Engineer
St. Paul District, Corps of Engineers
ATTN: NCSPD-PF
1135 U. S. Post Office & Custom House
St. Paul, Minnesota 55101

APPENDIX J

COST ESTIMATES

GENERAL REEVALUATION

AND

ENVIRONMENTAL IMPACT STATEMENT

SHEYENNE RIVER, NORTH DAKOTA

AUGUST 1982

(R 12/83)

APPENDIX J

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APPENDIX J

COST ESTIMATES

Estimated costs in this appendix are based on unit prices adjusted to reflect average bid prices received on comparable work done by the St. Paul District. Land costs are based on property values estimated by a real estate appraiser.

FIRST COSTS

Detailed estimates of first costs for the work recommended in this report are given in tables J-1, J-2, and J-3. The costs are at October 1981 price levels.

The estimated first cost of the levees and flood diversion channel at West Fargo/Riverside is $17,200,000 and is itemized in table J-1.

The estimated first cost of the flood diversion channel from Horace to West Fargo is $8,100,000 and is itemized in table J-2.

The estimated first cost of the 5-foot raise of Baldhill Dam is $31,100,000 and is itemized in table J-3. This estimate covers all costs associated with modification of the project, including modifications needed for upgrading the existing structure to meet current design criteria. The cost of upgrading the existing Baldhill Dam structure alone is estimated to be about $22,000,000. The cost estimate for upgrading is summarized in table J-4. The Dam Safety Evaluation Report prepared by the St. Paul District recommended upgrading the Baldhill Dam by construction of a new spillway on the left abutment and removing the old spillway. This recommendation results in an allocation of $9,100,000 to flood control ($31,100,000 - $22,000,000 = $9,100,000).

Table J-1 - Detailed estimate of first cost for levees and flood diversion channel around West Fargo and Riverside (M-29 to M-24)

Item	Unit	Quantity	Unit cost	Total cost
Lands and damages				
Lands				
Channels	Acre	108	$5,800	$626,400
Levees and offsets	Acre	259	5,800	1,502,200
Ponding areas	Acre	12	26,100	313,200
Improvements (one commercial structure, one light-industrial structure, and one multifamily complex)	Job	Sum	-	969,000
Relocation assistance payments (Public Law 91-646)	Job	Sum	-	20,000
Acquisition costs	Job	Sum	-	30,000
Contingencies	-	-	-	488,200
Total lands and damages				3,949,000
Relocations				
Utilities	Job	Sum	-	118,000
Contingencies	-	-	-	36,000
Total relocations				154,000
Roads, railroads, and bridges				
Bridges (new)				
12th Avenue North	Job	Sum	-	489,000
BN railroad	Job	Sum	-	795,000
U.S. Highway 10	Job	Sum	-	806,000
13th Avenue South	Job	Sum	-	538,000
Cass County 17	Job	Sum	-	452,000
Contingencies	-	-	-	556,000
Total new bridges				3,636,000

Table J-1

Detailed estimate of first cost for levees and flood diversion channel around West Fargo and Riverside (M-29 to M-24) (cont)

Item	Unit	Quantity	Unit Cost	Total Cost
Roads, railroads and bridges (cont)				
Bridges (removal)				
12th Ave. North	Job	Sum	-	$55,000
13th Ave. South	Job	Sum	-	55,000
Contingencies	-	-	-	22,000
Total bridge removals				132,000
Roads (new)				
Gravel road (SW corner of fairgrounds)	LF	1,000	$30.00	30,000
Cass County 19	LF	600	43.00	25,800
New Frontage Road, Hwy 10	LF	200	43.00	8,600
13th Ave. South	LF	700	43.00	30,100
Contingencies	-	-	-	14,500
Total new roads				109,000
Roads (removal)				
Gravel road (SW corner of fairgrounds)	LF	1,100	8.60	9,460
Cass County 19	LF	1,100	8.60	9,460
Gravel road south Hwy 10	LF	600	5.40	3,240
Bituminous road	LF	950	8.60	8,170
Hwy 10 frontage roads	LF	1,500	8.60	12,900
Contingencies	-	-	-	6,770
Total road removals				50,000
Railroad bypass (while railroad is rebuilt)	Job	Sum	-	795,000
Contingencies	-	-	-	129,000
Total bypass				924,000
Culverts				
Exterior channel				
Hwy 10 6X6 box	LF	184	355.00	65,320
RR 6X6 box	LF	136	355.00	48,280
12 Ave. 6X6 box	LF	192	355.00	68,160
Interior drainage				
RR pond outlet				
42" RCP	LF	88	73.00	6,424
42" gatewell	EA	1	5,400.00	5,400
42" sluice gate	EA	1	7,500.00	7,500
Fairgrounds pond outlet				
48" RCP	LF	176	73.00	12,848
Double 48" gatewell	EA	1	8,600.00	8,600
48" sluice gates	EA	2	7,500.00	15,000

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Table J-1

Detailed estimate of first cost for levees and flood diversion channel around West Fargo and Riverside (M-29 to M-24) (cont)

Item	Unit	Quantity	Unit Cost	Total Cost
Roads, railroads and bridges (cont)				
13th Ave. pond outlet				
54" RCP	LF	72	$97.00	$6,984
54" gatewell	EA	1	6,500.00	6,500
54" sluice gate	EA	1	9,700.00	9,700
13th Ave. culvert				
24" RCP	LF	50	21.00	1,050
Center Street culvert (Co. Rd. 17)				
78" RCP	LF	152	176.00	26,752
Drain 45/Co. Rd. 10 outlet				
60" RCP	LF	152	109.00	16,568
Double 60" gatewell	EA	1	12,900.00	12,900
60" sluice gate	EA	2	16,500.00	33,000
Old drain 21/Co. Rd. 10 (12 Ave.)				
72" RCP	LF	216	145.00	31,320
Contingencies	-	-	-	57,694
Total culverts				440,000
Total roads, railroads and bridges				5,291,000
Channels				
Diversion channel				
Common excavation (channels)	CY	812,200	1.34	1,088,348
Common excavation (berms)	CY	7,780	1.10	8,558
Fill (berms)	CY	216,340	1.00	216,340
Fill (short reaches of drain 21)	CY	77,950	1.00	77,950
Fill (short reaches of Sheyenne)	CY	57,000	1.00	57,000
Seeding (channel side slopes)	Acre	12	860.00	10,320
Seeding (berms)	Acre	121	860.00	104,060
Plantings	Job	Sum	-	253,700
Exterior drainage channel				
Common excavation	CY	116,395	1.34	155,969
Seeding	Acre	20	860.00	17,200
Interior drainage				
Excavation (ditches)	CY	127,420	1.34	170,743
Excavation (ponding areas)	CY	96,490	1.34	129,297
Seeding (ditches)	Acre	15	860.00	12,900
Seeding (ponding areas)	Acre	14	860.00	12,040
Contingencies	-	-	-	353,575
Total channels				2,668,000

Table J-1

Detailed estimate of first cost for levees and flood diversion channel around West Fargo and Riverside (M-29 to M-24) (cont)

Item	Unit	Quantity	Unit Cost	Total Cost
Levees				
Channel levees				
Stripping	CY	25,100	$2.15	$53,965
Fill	CY	271,870	1.00	271,870
Topsoil (from strippings)	CY	21,640	1.10	23,804
Seeding	Acre	41	860.00	35,260
Contingencies	-	-	-	58,101
Total channel levees				443,000
Tie-back levees				
Stripping	CY	19,850	2.25	44,663
Fill	CY	270,100	1.00	270,100
Topsoil	CY	20,785	1.10	22,864
Seeding	Acre	39	860.00	33,540
Contingencies	-	-	-	55,833
Total tie-back levees				427,000
Inspection trench				
Excavation	CY	184,160	1.34	246,775
Fill & compaction	CY	184,160	1.10	202,576
Contingencies	-	-	-	66,649
Total inspection trench				516,000
Total levees				1,386,000
Floodway control and diversion structures				
Sheyenne River control Structure (inlet)				
72" RCP	LF	300	145.00	43,500
Triple 72" gatewell	EA	1	22,600.00	22,600
72" sluice gates	EA	3	19,400.00	58,200
Sheyenne River control structure (outlet)				
72" RCP	LF	300	145.00	43,500
Triple 72" gatewell	EA	1	22,600.00	22,600
72" sluice gates	EA	3	19,400.00	58,200
Pump platform	EA	1	2,200.00	2,200

Table J-1

Detailed estimate of first cost for levees and flood diversion channel around West Fargo and Riverside (M-29 to M-24) (cont)

Item	Unit	Quantity	Unit Cost	Total Cost
Floodway control and diversion structures (cont)				
Diversion inlet structure (station 200+90)				
12" riprap	CY	675	$27.00	$18,225
Filter fabric	SY	2,000	3.25	6,500
Steel sheet piling	SF	1,985	17.20	34,142
Diversion outlet structure (station 2+70)				
12" Gabions	CY	670	70.00	46,900
Drain 21 inlet structure				
60" RCP	LF	632	109.00	68,888
60" flap gates	EA	2	1,600.00	3,200
Drain 21 outlet structure				
6X8 box culvert	LF	440	237.00	104,280
Landscaping	Job	Sum	-	43,000
Contingencies	-	-	-	96,065
Total floodway control and diversion structures				672,000
Total direct costs				14,120,000
Indirect costs				
Engineering and design				1,992,000
Supervision and administration				
Supervision and inspection				636,000
Overhead				452,000
Total indirect costs				3,080,000
Total project costs				17,200,000

(R 1/84)

Table J-2

Detailed estimate of first cost for Horace to West Fargo Diversion (M-42 to M-24)[1]

Item	Unit	Quantity	Unit Cost	Total Cost
Lands and damages				
Lands	Acre	250	$1,600.00	$400,000
Acquisition costs	Job	Sum	-	28,000
Contingencies	-	-	-	65,000
Total lands and damages				493,000
Relocations				
Utilities	Job	Sum	-	45,000
Contingencies	-	-	-	7,000
Total relocations				52,000
Roads, Railroads and bridges				
Bridges (new)				
I-94 (W.B.L.)	Job	Sum	-	538,000
I-94 (E.B.L.)	Job	Sum	-	538,000
Cass County Rd	Job	Sum	-	430,000
Cass County Rd	Job	Sum	-	430,000
Contingencies	-	-	-	290,000
Total new bridges				2,226,000
Bridges (removal)				
I-94 (W.B.L.)	Job	Sum	-	86,000
I-94 (E.B.L.)	Job	Sum	-	86,000
Three Cass County roads	Job	Sum	-	161,000
Contingencies	-	-	-	50,000
Total bridge removals				383,000
Roads (new)				
Seven Cass County roads	LF	7,000	43.00	310,000
Contingencies	-	-	-	45,000
Total new roads				355,000
Roads (removal)				
Five Cass County roads (for Texas crossings)	LF	5,000	8.60	43,000
Two Cass County roads (for new bridge sites)	LF	2,000	8.60	17,200
Contingencies	-	-	-	9,800
Total road removals				70,000

(R 12/83)

Table J-2
Detailed estimate of first cost for Horace to West Fargo Diversion (M-42 to M-24)[1] (cont)

Item	Unit	Quantity	Unit Cost	Total Cost
Roads, Railroads and bridges (cont)				
Culverts				
Five Texas crossings				
(two 24" RCP)	LF	250	$21.50	$5,375
Contingencies	-	-	-	625
Total culverts				6,000
Total roads, railroads and bridges				3,040,000
Channels				
Diversion channel				
Common excavation	CY	1,300,000	1.34	1,742,000
Seeding	Acre	210	860.00	180,600
Contingencies	-	-	-	289,400
Total channels				2,212,000
Levees				
Channel berms	Job	Sum	-	484,000
Contingencies	-	-	-	73,000
Total levees				557,000
Floodway control and diversion structures				
Sheyenne River control structure at Horace				
(8X10 box culverts)	LF	300	408.50	122,550
12" Riprap	CY	800	26.88	21,504
Diversion inlet structure at Horace				
12" Riprap	CY	675	26.88	18,144
Filter fabric	SY	2,000	3.23	6,460
Steel sheet piling	SF	1,985	17.20	34,142
Landscaping	Job	Sum	-	43,000
Contingencies	-	-	-	36,200
Total floodway control and diversion structures				282,000
Total direct cost				6,636,000
Indirect costs				
Engineering and design				940,000
Supervision and Administration				
Supervision & inspection				310,000
Overhead				214,000
Total indirect Federal costs				1,464,000
Total project cost				8,100,000

[1] Note: This diversion has to be coupled with the levees and diversion around West Fargo/Riverside alternative to effectively reduce flood damages.

Table J-3

Detailed estimate of first costs for 5-foot raise of Baldhill Dam

Item	Unit	Quantity	Unit Cost	Total Est. Cost
Lands and damages				
Lands (fee title)	Acre	2,000	$585.00	$1,170,000
Lands (fee title on lands presently in easement)	Acre	666.15	296.00	197,180
Improvements (97 cabins, 6 farms, 2 church camps, 2 multifamily dwellings, and other miscellaneous structures	Job	Sum	-	2,248,000
Acquisition costs	Job	Sum	-	300,000
Relocation assistance payments (Public Law 91-646)	Job	Sum	-	240,000
Contingencies	-	-	-	364,820
Total lands and damages				4,520,000
Relocations				
Recreation facilities (relocation)				
Removal of roads, parking lot, etc.	Job	Sum	-	38,000
Beautification measures	Job	Sum	-	22,000
Sewage treatment plant	Job	Sum	-	150,000
Beach	Job	Sum	-	50,000
Visitor center/multiuse building	Job	Sum	-	300,000
Relocate concessions	Job	Sum	-	20,000
Relocate picnic area	Job	Sum	-	30,000
Access & circulation roads	Job	Sum	-	245,000
Relocate camping facilities	Job	Sum	-	45,000
Contingencies	-	-	-	180,000
Subtotal recreation facilities relocations				1,080,000
Building, grounds, and facilities (relocation)				
Service and storage buildings	Job	Sum	-	50,000
Utilities for buildings	Job	Sum	-	10,000
Landscaping and fencing	Job	Sum	-	5,000
Access and circulation roads	Job	Sum	-	30,000
Contingencies	-	-	-	15,000
Subtotal buildings, grounds and facilities relocations				110,000
Total relocations				1,190,000
Reservoir				
Boundary surveys and monumenting	Job	Sum	-	215,000
Total reservoir				215,000

 (R 12/83)

Table J-3

Detailed estimate of first costs for 5-foot raise of Baldhill Dam (cont)

Item	Unit	Quantity	Unit Cost	Total Est. Cost
Dam				
Embankment				
Excavation	CY	45,600	$2.15	$98,040
Random fill	CY	148,300	1.10	163,130
Riprap removal	CY	8,440	6.45	54,438
Pervious fill	CY	12,200	3.25	39,650
Impervious fill	CY	109,700	2.75	301,675
Gravel fill	CY	4,850	3.75	18,188
Filter blanket	CY	24,640	13.00	320,320
Riprap	CY	9,700	23.50	227,950
15" PVC	LF	1,320	16.00	21,120
Manholes	EA	5	2,100.00	10,500
Contingencies	-	-	-	188,989
Subtotal embankment				1,444,000
Spillway				
Excavation	CY	574,100	2.15	1,234,315
Filter blanket	CY	45,320	13.00	589,160
Riprap	CY	71,860	23.50	1,688,710
Concrete	CY	41,800	275.00	11,495,000
Tainter gates & operating equipment	Job	Sum	-	1,450,000
Remove existing spillway	Job	Sum	-	630,837
Contingencies	-	-	-	2,563,978
Subtotal spillway				19,652,000
Cofferdam				
Random fill	CY	6,465	3.25	21,010
Pervious fill	CY	101,900	4.30	438,170
Contingencies	-	-	-	68,820
Subtotal Cofferdam				528,000
Total dam				21,624,000
Fish and wildlife facilities				
Fish rearing ponds	EA	11	31,500	346,500
Hatchery building	Job	Sum	-	130,000
Fencing	Miles	4	3,500	14,000
Contingencies	-	-	-	79,500
Total fish and wildlife facilities				570,000
Engineering and design	-	-	-	1,420,000
Supervision and administration				
Supervision and inspection				1,090,000
Overhead				471,000
Total supervision and administration				1,561,000
Total project costs				31,100,000

(R 12/83)

Table J-4 - Summary of estimated first cost for upgrading Baldhill Dam (Option 1 - no raise of embankment, new spillway, and removal of existing spillway)

Item		Cost
Relocations		$1,190,000
Dam		17,805,000
Embankment	(1,044,000)	
Spillway	(15,566,000)	
Cofferdam	(528,000)	
Fish and wildlife facilities		570,000
Engineering and design		1,208,000
Supervision and administration		1,227,000
Total project costs		22,000,000

AVERAGE ANNUAL COSTS

The total average annual costs for the project are estimated at $3,003,900 and are summarized in table J-5. The interest and amortization factor used was 0.076299 which represents a 7 5/8-percent interest rate over a 100-year period.

Table J-5 - Summary of estimated annual charges for the selected plan

Item	Cost	
Raise of Baldhill Dam		
Construction cost	$9,100,000 (1)	
Interest during construction (2)	1,071,000	
Total first cost	10,171,000	
Annualized cost (3)(4)		$757,700
Annual operation and maintenance cost (increase)		10,000
Total average annual costs		767,700
Levees and flood diversion channel at West Fargo/Riverside		
Construction cost	17,200,000	
Interest during construction (2)	2,268,000	
Total first cost	19,468,000	
Annualized cost (3)		1,483,900
Annual operation and maintenance costs		46,000
Total average annual costs		1,529,900
Flood diversion channel - Horace to West Fargo		
Construction cost	8,100,000	
Interest during construction (2)	829,300	
Total first cost	8,929,300	
Annualized cost (3)		681,300
Annual operation and maintenance costs		25,000
Total average annual costs		706,300
Total first costs		34,400,000 (5)
Total average annual costs		3,003,900

(1) Only that portion of costs assigned to flood control (i.e., for Baldhill Dam: $31,100,000 - $22,000,000 = $9,100,000).
(2) Based on a 3-year construction period at 7 5/8-percent interest using compound interest procedures.
(3) Interest and amortization factor for 100-year period at an interest rate of 7 5/8 percent is 0.076299.
(4) The relocation assistance payment costs (Public Law 91-646) were removed from th e construction cost of the project when the annualized cost was computed.
(5) Does not include costs associated with the upgrading of Baldhill Dam for Dam Safety Assurance reasons.

APPENDIX K

GEOTECHNICAL DESIGN CONSIDERATIONS

GENERAL REEVALUATION

AND

ENVIRONMENTAL IMPACT STATEMENT

SHEYENNE RIVER, NORTH DAKOTA

AUGUST 1982

APPENDIX K

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APPENDIX K

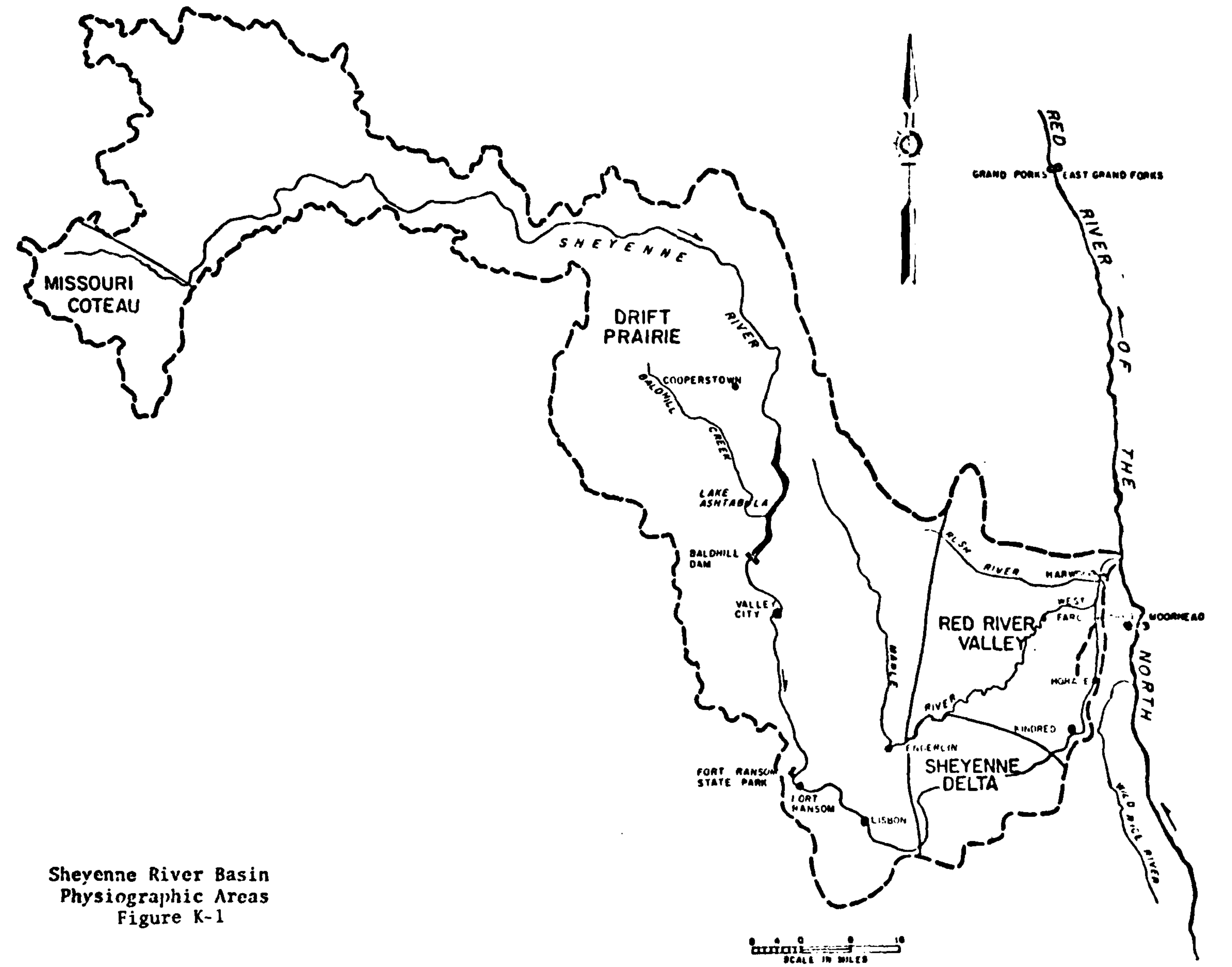
GEOTECHNICAL DESIGN CONSIDERATIONS

INTRODUCTION

The geotechnical design considerations pertinent to the proposed Sheyenne River flood control plan are presented in the following sequence. The physiography associated with the Sheyenne River basin is presented initially and is followed by a brief discussion of geologic aspects important to the proposed plan. Existing conditions and the proposed modification at Baldhill Dam are then presented and are followed by a discussion of the proposed West Fargo diversion. The modification of Baldhill Dam, the West Fargo diversion, and possibly other presently undetermined diversions appear, at this time, to be the features of the proposed plan for which the Corps of Engineers would have design responsibility.

PHYSIOGRAPHY

The Sheyenne River basin lies in portions of four major physiographic areas, or features, which were formed during the Pleistocene Epoch and have suffered little modification by subsequent erosion and deposition. These features, shown on figure K-1, are the Missouri Coteau, Red River Valley, Sheyenne Delta and Drift Prairie. All except the Missouri Coteau are part of the Central Lowlands physiographic province and provide uniform, convenient reference units for discussion of the geology pertinent to the evaluation of flood control alternatives. Only the extreme western tip of the basin lies in the Missouri Coteau which is part of the Great Plains physiographic province. This area is



Sheyenne River Basin
Physiographic Areas
Figure K-1

remote from alternatives considered and is, therefore, mentioned only for completeness and is not discussed.

Since the physiography of the basin is closely related to Pleistocene and recent geologic events, that portion of the geologic history is presented briefly. During the Pleistocene Epoch, glaciers advanced several times over an eroded Cretaceous and pre-Cretaceous bedrock surface and deposited glacial drift that ranges from a few feet to more than 300 feet in thickness. As the last glacial ice mass receded northward, it formed a barrier to the northerly drainage of the area. This barrier caused a large lake, Lake Agassiz, to be formed in the present Red River Valley. The Sheyenne River, swollen with glacial meltwater, flowed into the lake and deposited large quantities of sediment which formed the Sheyenne Delta at the mouth of the river. With continued retreat of the glacier, Lake Agassiz receded from the area and the present drainage was established.

The Red River Valley represents the nearly flat bed of Lake Agassiz and ranges in elevation from 890 mean sea level near the mouth of the Sheyenne River to 1000 at the margin of the Sheyenne Delta west of Kindred. A low escarpment marks the eastern edge of the delta above elevation 1000. West of the delta front the upland elevations range from 1020 to 1700. The Drift Prairie is characterized by a gently undulating to hilly surface that is poorly drained by the Sheyenne River and its tributaries. The Sheyenne River valley varies in depth from 100 to 200 feet and ranges in width from 1/4 to 2 miles in the Drift Prairie and Sheyenne Delta areas. In the Red River Valley the river flows in a meander belt 1/4- to 1/2-mile wide with no well defined valley. Natural woodlands are restricted to the river corridor. The rest of the basin

is prairie that is cultivated and pastured.

GEOLOGY

The geology and groundwater of the Sheyenne River Basin are discussed in Appendix K, Phase I, General Design Memorandum Working Papers, Stage 2 Documentation. Therefore, only new information or those geologic aspects important to the considered alternatives are discussed.

Red River Valley

The geology pertinent to the construction of levees and channels in the Red River Valley is a product of sedimentation in glacial Lake Agassiz which existed in two phases separated by a period of subaerial erosion. Sediment laid down in the first phase consists of dark gray to black, highly plastic clay. This clay rests on top of glacial drift and averages 60 feet in thickness in the area between Kindred and the mouth of the Sheyenne River. A uniform bed of laminated silt and clay deposited in the second Lake Agassiz phase mantles the lower clay unit and is 15 to 25 feet thick in the area. Occasional buried channels that were cut and filled during the interlake phase occur between the two lacustrine units, and low sandy beach ridges occur at the surface but are generally west of the sites of proposed work. The lower lacustrine clay is notorious in the area for its poor foundation and slope stability characteristics. Although the upper unit of laminated silt and clay is more competent, it is more easily eroded by running water and has been a problem element in improperly designed or constructed drainage ditches. The lacustrine clays are underlain by 100 to 250 feet of glacial drift which rests on Precambrian granite and Cretaceous shale.

Sheyenne Delta

The Sheyenne Delta is composed of sand, silt and clay that grade from coarse in the west to fine in the east. The texture and distribution of the sediments are discussed in detail in previous studies dealing with the Kindred Dam alternative. An existing high water table was a source of concern in the evaluation of Kindred Dam, and a study by the United States Geological Survey (USGS) in 1979 showed the water table could be raised 1.0 foot as far as 4 miles from the river valley. Preliminary estimates from a subsequent refinement of that study by the USGS indicate the 1.0-foot change would only extend about one mile or less from the valley. Although the Kindred Dam alternative is not considered in this report, the more recent study of impact on the water table is reported to ensure a record of the complete evaluation.

Drift Prairie

The Drift Prairie is mantled by glacial drift, primarily sandy clay till, with a thickness of a few to over 200 feet, that overlies Cretaceous shale bedrock. Bedrock is exposed along the Sheyenne River valley upstream of Fort Ransom. Except for exposures of the Niobrara Formation near Fort Ransom, the exposed bedrock is the lower portion of the Pierre Formation. That portion of the formation is unstable and fails readily by slumping where exposed in road cuts, along the river valley and the shoreline of Lake Ashtabula. Slope failures also frequently occur at the glacial till-shale contact where it is exposed by erosion or excavation.

Modification of Baldhill Dam is the only major structural alternative proposed in the Drift Prairie and includes a raise of up to 5 feet in the embankment and a new spillway. The site geology, illustrated by profiles

on plate K-3, consists of glacial drift overlying Cretaceous shale of the Pierre Formation in the abutments and alluvial valley fill overlying the Pierre Formation under the valley floor.

On the right abutment, gravelly sandy clay till rests on shale between elevation 1260 and 1280. This contact was a weak plane responsible for failure of the overlying slope where exposed along the existing spillway discharge channel. The slope was finally stabilized by construction of a shear wall founded in the shale. A till-filled preglacial valley exists under the left abutment and is separated from the present valley by a buried shale ridge. The valley and ridge are obscured by a thick cover of drift and are not apparent at the ground surface. Glaciofluvial sand and gravel deposits cap the till above elevation 1270 on the left abutment. The valley alluvium averages about 50 feet in thickness and consists primarily of clay with thin, discontinuous beds of sand and gravel throughout.

The Pierre Formation is represented by the Gregory and Pembina Members which are characterized by undesirable engineering properties. The members contain a higher frequency of bentonite seams than those higher in the formation and are generally unstable where exposed in road cuts or by erosion along the river valley.

The water table at the site has not been defined and is inferred on the geologic profiles. Free water below the water table would be available only in sandy phases of the drift and alluvium.

Subsurface investigation indicates the new spillway, as proposed, would be

partially founded on shale and partially founded on till.

BALDHILL DAM

General

The existing Baldhill Dam, which was constructed during the period from 1947 to 1950, consists of a 1650-foot-long earth embankment and a 160-foot-wide concrete control structure. Discharges are regulated by three 16-foot-high by 40-foot-wide tainter gates and two 3-foot-diameter low flow conduits. The low flow conduits are located in the central tainter gate piers. At normal pool elevation 1266.0, the pool extends 27 miles upstream and contains 70,700 acre-feet of water. The embankment has a 20-foot-top width and a maximum height of about 60 feet at the old river channel. The embankment was constructed with symmetrical upstream and downstream slopes. From top of dam elevation 1278.5 to elevation 1270.0 the slopes were 1V on 2H, from elevation 1270.0 to elevation 1253.0 the slopes were 1V on 2½H, and from elevation 1253.0 to the stripping line the slopes were 1V on 3H. A disposal berm was placed against the upstream slope from the natural ground surface to a minimum elevation of 1245.0. A minimum stripping depth of 12 inches was required over the full base width of the embankment, but no core (or inspection) trench was required. Internal drainage was provided by a 3-foot-thick drainage blanket placed on the stripping line for the downstream one-fifth of the embankment base width. Slope protection upstream, and below elevation 1253.0 downstream, consisted of 12 inches of riprap placed on 6 inches of gravel. On the downstream slope, above elevation 1253.0, 6 inches of topsoil was placed and seeded. The embankment crest was protected with 6 inches of stabilized gravel. Construction drawings indicate that

the embankment material consists of lean clay and more pervious materials downstream of the embankment centerline and fat clay and shale upstream of the embankment centerline.

Postconstruction Modifications

Modifications subsequent to construction include upstream riprap repair, control of surface runoff and foundation seepage in the downstream toe area, stabilization of a slide on the right abutment above the discharge channel, extension of the slope protection on both sides of the discharge channel as well as on the right side of the approach channel, and the construction of a tailwater control structure in the discharge channel. The riprap extensions in the channels and the tailwater control structure are listed for completeness and are not particularily significant with regard to the proposed modification of Baldhill Dam presented later.

The upstream riprap repair was required because of erosion of the original slope protection during periods of high wave action. The repair consisted of flattening the upstream slope and placement of new upstream slope protection. The upstream slope is now 1V on 2½H from the embankment crest to the surface of a small berm which was constructed to elevation 1254.0 prior to placing the new slope protection.

Immediately downstream of the dam, wet conditions existed for several years due to both the ponding of surface runoff and the emergence of a significant amount of foundation seepage in the vicinity of station 15+50 to 16+50. The foundation seepage occurs through a 2- to 5-foot-thick zone of sand, gravel, and cobbles located 3 to 8 feet below the original groundline between about station

14+00 and the concrete spillway. This pervious zone is probably exposed in the spillway approach channel and may also be connected to the pool through the sand backfill placed behind the upstream left wingwall of the spillway. Because there was no core (or inspection) trench required, the pervious zone was not cut off when the embankment was constructed. To control the foundation seepage, and prevent its emergence at the ground surface near the downstream toe, an 8-inch subdrain has been installed in the pervious zone to collect the foundation seepage and convey it to the discharge channel downstream of the spillway. To improve surface drainage in the downstream toe area a ditch has been excavated about 110 feet downstream of the embankment toe to drain surface runoff to the old river channel. Between the ditch and the embankment toe, up to 3 feet of berm fill has been placed to provide positive surface drainage to the ditch.

The excavation for the original construction of the spillway and associated approach and discharge channels triggered overburden slides in the right abutment. The abutment consists of glacial till overlying shale bedrock. The shale surface has a slight downward slope toward the valley and the slides occurred along the saturated, sloping glacial till-shale contact. Intermittent movements of the overburden slides above the stilling basin and discharge channel and above the approach channel continued subsequent to construction. A 450-foot-long shear wall was finally installed about 95 feet upslope from the stilling basin and discharge channel to stabilize the downstream slide area. The shear wall consists of a vertical pile wall anchored in the firm underlying shale and extending 4 feet into the overburden material. Since its installation the shear wall has been effective in preventing overburden movement above the stilling basin and the discharge channel. To date no attempt has been made to stabilize the upstream slide area above the approach channel.

Evaluation of Present Conditions

There are two major concerns with regard to present conditions at Baldhill Dam. Because of the steep side slopes, the embankment does not meet current slope stability requirements for sudden drawdown and steady seepage. Preliminary slope stability analyses indicate that IV on 3.5H slopes are required to meet the current criteria. Also the dam does not have sufficient spillway capacity to prevent the embankment from being overtopped during relatively rare floods. Since the dam is high hazard with respect to the National Dam Safety Assurance classification system, extensive modification of the dam will be required to correct these two major deficiencies. The required modification may be accomplished either as part of the more extensive Sheyenne River flood control project or as a separate project under the Dam Safety Assurance program. In either case the required modifications will be extensive, though not necessarily identical.

Factors other than the embankment stability and the spillway capacity that should be considered in any proposed modification include the intermittent cracking and gradual spreading of the embankment crest, tilting of the spillway walls, heaving of the spillway chute and stilling basin slabs caused by rebound in shale foundation, seepage exiting on the discharge channel slope adjacent to the left wingwall of the stilling basin, repair and maintenance of the discharge channel slope protection, and the foundation seepage and right abutment slides mentioned earlier.

Intermittent cracking of the embankment crest near both the upstream and downstream shoulders has been observed over the years. No vertical displacement occurs at the cracks and they self-heal with time. Separation pins installed

across the embankment crest indicate that the crest is spreading at a fairly constant rate of about 0.85 inch per year. Two slope indicators installed near the upstream shoulder of the embankment indicate that the spreading is confined to the upper 10 to 20 feet of the embankment. The slope indicators, including two installed at the downstream toe, do not show any significant movements in the foundation soils or at depths in excess of 20 feet within the embankment. The gradual spreading and intermittent cracking of the crest are probably related phenomena and are believed to be caused by a combination of settlement, freeze-thaw, seasonal moisture changes, and possibly slow creep of the steep slopes in the upper portion of the embankment. Regardless of the cause, the slope flattening required to meet current stability criteria should eliminate, or significantly reduce, the cracking and gradual spreading once consolidation caused by the added fill is complete.

The foundation seepage discussed previously is currently controlled by a subdrain installed in the pervious zone; however, a positive cutoff of the pervious zone is preferred and should be installed when the embankment is modified.

Since the plan presented in this report includes a new spillway on the left abutment and removal of the existing spillway, conditions of the existing spillway and associated approach and discharge channels are significant only to the extent that they indicate potential problems to be evaluated in the final design.

Proposed Plan

The proposed plan for a 5-foot raise of Baldhill Dam is shown on plate K-1. Although the raise that will ultimately be recommended for final design has

not been precisely determined at this time, it appears highly unlikely that the raise will exceed 5 feet. Thus, the plan shown on plate K-1 for a 5-foot raise is considered to be a reasonable representation of what the final modifications will actually be. Note that the new spillway, capable of discharging the probable maximum flood will be constructed on the left abutment. Once the embankment modification is essentially complete and the new spillway is operational, the existing spillway will be cofferdammed off and then partially or completely removed. The embankment will then be extended across the existing spillway area and the existing discharge channel will be filled. The material in the cofferdam upstream of the existing structure could then be used to fill the existing approach channel. This would tend to stabilize the upstream right abutment slide. Stabilization of the slide would not be necessary, but may be desirable.

A typical section showing the proposed embankment modification is shown on plate K-2. It is anticipated that the embankment modification will have to be accomplished with the pool at, or above, elevation 1236.0. Therefore, the centerline of the raised embankment will be about 40 feet downstream of the existing centerline so that the major portion of the modification will be on the downstream side of the existing embankment. Work on the upstream side of the embankment below pool level will be limited to the placement of clean pervious fill and riprap slope protection. The crest width of the embankment will be increased to 30 feet and both the upstream and downstream slopes will be flattened to 1V on 3½ H to meet current slope stability requirements. The existing downstream riprap will be salvaged and the remaining downstream area beneath the new impervious fill section will be stripped to a minimum depth of 6 inches. Existing riprap to be removed on the upstream slope will be placed

underwater between elevation 1254.0 and pool level to flatten the upstream slope. Internal drainage will consist of the sand drain and 15-inch-diameter perforated pipe toe drain shown on the typical section. The toe drain will discharge into the stilling basin of the new spillway. Impervious fill for the embankment will be obtained from the excavation for the new spillway and associated approach and discharge channel. New upstream slope protection above pool level will consist of 24 inches of riprap placed on 12 inches of bedding. Downstream embankment slope protection will consist of 4 inches of topsoil and seeding. The embankment crest will be protected with 6 inches of stabilized aggregate. Should a decision be made to place a vehicle bridge across the new spillway, the crest would be revised to incorporate a wider top width, 6 inches of stabilized aggregate base course, and bituminous paving.

The random fill berm shown on the downstream side of the embankemnt provides a disposal area for approximately 340,000 cubic yards of excess excavation from the new spillway and is not required for embankment stability. The berm, which was added after stability analyses had been performed, would permit steepening the downstream embankment slope. However, considering the excess excavation available, it was decided to keep the downstream slope at 1V on 3½H for ease of maintenance. Stripping of the existing ground surface beneath the berm will not be required. Erosion protection on the surface of the berm will consist of 4 inches of topsoil and seeding.

Construction of the berm, along with excavation of the discharge channel, will obliterate several of the existing fish rearing ponds located downstream of the dam. Relocation of the fish rearing facilities will, therefore, be required.

Subsurface Data

Only limited subsurface data is presented for Baldhill Dam in order to significantly reduce the number of plates required and to restrict the level of detail to that justified by the current stage of the study. Boring logs and soil strength data have, therefore, been limited to the abbreviated boring logs shown on the geologic profiles on plate K-3 and to the tabulated soil strength data given below. The abbreviated boring logs, the tabulated soil strength data, and the performance history of the existing dam provide a reasonable basis for evaluating the proposed modification of the dam.

Undisturbed Soil Strength Parameters*

Material	Q-Strengths		R-Strengths		S-Strengths	
	Ø (degrees)	C (pcf)	Ø (degrees)	C (pcf)	Ø (degrees)	C (pcf)
Existing Embankment Fill	14.6	2080	16.9	260	28.1	0
Remolded Embankment Fill	3.2	1720	13.7	340	23.9	0
Existing Channel Fill	0	300	17.2	300	29.0	0
Alluvial Material (upper)	2.2	400	16.6	500	28.2	0
Alluvial Material (middle)	2.9	1200	15.3	820	23.5	0
Alluvial Material (lower)	0	320	13.9	240	27.0	0

*Results of tests performed in 1977 on 5-inch-diameter Shelby samples.

Foundation Conditions

The foundation conditions at Baldhill Dam are shown on the geologic profiles on plate K-3. The locations of the borings used to develop geologic profiles are shown on plate K-1. The alluvial material overlying the shale bedrock in the valley has a maximum depth of about 50 feet, consists primarily of clays, and is relatively compressible. A foundation settlement gage installed on center-

line at station 12+75 during construction indicates a total settlement of about 2.6 feet due to the 43 feet of existing embankment fill. About 0.9 foot of the total settlement has occurred since the embankment was completed in December 1947. The compressibility of the alluvial material precludes founding concrete control structures on this material.

The right abutment consists of glacial till overlying shale bedrock. The shale surface has a slight downward slope toward the valley and the glacial till-shale contact zone is saturated. Founding the existing structure on the shale bedrock avoided the settlement problems associated with the alluvial material in the valley, but the potential for sliding of the glacial till overburden on the saturated glacial till-shale contact apparently was not recognized until such slides actually occurred during construction. Intermittent sliding of the glacial till overburden above the approach channel has continued to occur since construction. Similar sliding above the stilling basin and discharge channel was stabilized by the shear wall installation discussed previously.

The left abutment consists of glaciofluvial deposits of sands and gravels overlying the glacial till which, in turn, overlies the shale bedrock. The new spillway will be located in the left abutment to avoid the compressible alluvial material in the valley, to simplify cofferdamming, and to avoid the overburden slides associated with the existing spillway location on the right abutment. To minimize excess excavation the spillway will be located as far valleyward as practical, considering foundation conditions, and the spillway will be skewed with respect to the embankment centerline. The excess excavation quantity for the spillway location shown is about 340,000 cubic yards, and the quantity increases rapidly as the spillway is moved farther into the abutment. The ex-

cavated material will consist primarily of glacial till, with significantly lesser amounts of shale, alluvial material, and glaciofluvial sands and gravels. The glacial till is an excellent embankment material and will be used for the impervious fill portion of the modified embankment. Excess excavation will be placed in the random fill disposal berm at the embankment toe and in the existing discharge channel. The surface glaciofluvial sands to the left of the new spillway will be cut off with a conventional core trench excavated to the glacial till and extending approximately 100 feet into the abutment from the spillway excavation.

On the basis of the existing borings it appears that the concrete spillway will be founded primarily on the shale bedrock, but that portions of the structure may be on glacial till. If future borings verify that the structure is founded on both shale and glacial till, then special foundation treatment such as overexcavation may be required to ensure reasonably uniform foundation-structure interaction. Considering the performance of the existing structure, an anchorage system will probably be required to eliminate, or control, rebound in the shale foundation beneath the new structure. The stilling basin and chute slabs of the existing spillway contain anchors spaced 7 to 10 feet apart that extend 8 feet into the shale. To date the slabs show a maximum rebound of about 4½ inches relative to the spillway side walls. Relative to adjacent slabs, the rebound has been fairly uniform with negligible vertical displacement at joints between slabs.

The foundation seepage discussed previously, and which the slurry trench is designed to cut off, occurs through the GP-GC zone at elevation 1236 to 1240 in boring 73-24 shown just to the left of the existing spillway on the geologic profile.

Future Subsurface Investigations

Additional boring and testing will be necessary to obtain adequate subsurface data for final design. Assuming the modification will be as proposed herein, the principal area needing further investigation is the left abutment. Specifically, better definition of elevation and slope of the shale surface is required at the spillway structure location and beneath the left cut slopes of the approach and discharge channels. Strength, compressibility and rebound characteristics of the shale will be needed for design of the spillway structure, and remolded strengths of the glacial till are needed to refine the embankment stability analyses. In the valley, additional strength tests and consolidation tests are necessary in order to refine foundation strength parameters to be used in future stability analyses and to predict embankment settlement. Some boring and testing of the foundation soils along upstream cofferdam alignments is also anticipated.

Stone and Aggregate Construction Materials

Aggregate materials and good quality field stone for riprap are available within a 20-mile radius of the dam.

WEST FARGO DIVERSION

General

The materials present at West Fargo and much of the lower Sheyenne River valley can be easily recognized and correlated with materials found elsewhere in the Red River Valley. They are the lacustrine sediments and underlying

glacial deposits. Boring logs in areas of various diversion channel alignments are on plate K-4. A brief description of the two major formations is given in the following paragraphs.

Lacustrine Sediments

Lacustrine sediments are present throughout the entire Lake Agassiz region. In the West Fargo project area they consist of two units that can be traced over most or all of the region. The upper unit is composed of clays, silty clays and silts; it is easily recognized by its texture and light brown color where oxidation has occurred. Geologic studies have further subdivided this unit, but because of the difficulty in accounting for many of the differences in engineering properties relevant to this study and the limited data available, further subdivision was considered inappropriate. It is likely that at many locations the top few feet of soil are fluvial, or windblown, deposits. For the purposes of stability analysis no distinction is made for any differences in the properties of fluvial sediments within the upper unit. In the West Fargo area the upper lacustrine unit extends from 13 to 18 feet in depth with liquid limits varying from 80 to 111 percent. A silt seam was found in this unit at boring 79-11M. The silt had a liquid limit of 30 percent. Moisture contents vary from 22% in the desiccated surface layers to 48% in deeper layers. At scattered locations and depths this unit may exhibit slickensided surfaces upon shearing or breaking. The base of this unit is at approximately elevation 881 where it meets the top of the lower lacustrine unit.

The lower lacustrine unit is composed of dark gray to black clay and is desiccated for the first few feet as a result of a temporary glacial retreat that allowed lake levels to fall during the period in which the Lake Agassiz sediments were being deposited. The unit becomes siltier with depth until it

gradually changes into glacial till at approximately elevation 825, making the unit typically 50 to 60 feet thick. Liquid limits vary from 70 to 130 percent and plastic limits vary from 22 to 40 percent. The lower liquid and plastic limits are found deep, near or within the transition to glacial till. Moisture contents have been shown to be the best variable to correlate the unit between locations, and typically vary from 50 to 80 percent with lower values found both deep and within the zone of desiccation at the top of the unit. All the lacustrine sediments, but especially the lower unit, have a record of being notoriously poor foundation materials throughout the entire Lake Agassiz region. This unit consistently exhibits slickensides upon shearing.

Glacial Sediments

Glacial sediments underlie the lacustrine clay throughout the region. These sediments consist of gray clay with lower Atterberg limits and higher shear strengths than the lacustrine deposits. Having been saturated and washed by the waters of Lake Agassiz, the upper zone of the till immediately under the lacustrine sediments is generally softer. The glacial till was penetrated by borings for the project in nearby Fargo-Moorhead. Borings taken in West Fargo did not reach the till.

Levees and Channels

The flood barrier will confine the diversion channel through the city of West Fargo and protect the city from overland flows where other barriers, such as the freeway embankment and railroad embankments, do not. Approximately 42,000 lineal feet of impervious levee will parallel the diversion channel. All levees will have a minimum of a 10-foot top width and 1V on 3H side slopes. Greater top widths may be used to spoil excess excavation should

this be necessary.

The diversion through West Fargo will for the most part follow County Drain 21 for 6,000 of the 21,000-foot length. It will have a 55-foot bottom width with 1V on 3H side slopes rising to a berm not more than 16.5 feet higher than the channel bottom. The diversion channel from Horace to West Fargo will be shallow and very wide with very low velocities.

Structures

Closure structures will consist of gated large-diameter culverts passing through an earth embankment. These structures will most probably be founded on fluvial soils where settlement could be a concern. For this reason they are presently planned to be located far enough from bridges and other structures to prevent inducing damages. Should stability prove a concern in future studies, berms may be extended upstream and downstream.

Flood Emergency Levees

During the floods of 1969, 1975, 1978 and 1979 emergency levees were built, or raised, mostly along the banks of the Sheyenne River to protect the city of West Fargo. Some of these levees were originally built using sandbags but raised to final grade with clay placed over the sandbags by equipment. Portions of these have since been removed. Other emergency levees were built to protect from overland flows. These were constructed of clay. Although at the time of this writing no firm alignment has been selected, it is not anticipated that new construction will parallel the existing emergency works.

Engineering Characteristics of the Lake Agassiz Deposits

Within the last half century the Red River Valley has witnessed many foundation failures. Although the most famous of these failures is the Transcona Grain Elevator near Winnipeg, serious problems have occurred during construction of all types of structures, including buildings, bridges, and levees. Evidence of distress is almost invariably noticed during or immediately following construction. Experience has shown that in almost all cases the problems can be traced to a deposit of slickensided lacustrine clay of varying thickness. This layer characteristically has high liquid limits, ranging from 70 to 130 and moisture contents ranging from 50 to 80 percent. Although this deposit (lower lacustrine) has an overconsolidation ratio of 2 to 3, there is no geologic evidence to indicate that this deposit has ever been subjected to a load much in excess of the present overburden pressure. The high overconsolidation ratios, therefore, are probably caused by desiccation and by the highly active mineral constituents of the deposit and the ability of these minerals to form diagenetic bonds. Of great importance is the fact that the results of laboratory shear strength tests on undisturbed samples from this deposit do not necessarily correspond to actual in-place field performance. Research done by Hill and Rutledge[1] indicate a definite decrease in laboratory shear strength with increasing sample size. One reason for the descrepancy between the laboratory results and the in-situ performance is the brittle nature of stress-strain characteristics of the material. Undrained shear tests on samples for this deposit characteristically have peak strengths at very low strains with large postpeak decrease in strength. It is felt that these peak strengths may be a laboratory phenomenon induced by rapid loading rates. Triaxial testing of the lower unit from Pembina, North Dakota, in 1968 and 1975 has shown that a reduction of strain rate from 2% to 1% reduced peak strengths by almost half. Tests performed at a strain rate of 1% generally did not show

nearly as much reduction in postpeak strength. It is believed that the faster strain rate does not allow sufficient time for realistic pore pressure and strain distribution within the sample and probably results in an unrealistically high peak strength. Postpeak strengths were not considered during testing and analysis at the nearby Fargo-Moorhead project and this data is of marginal value for projections at West Fargo. This brittle characteristic is often not found in the upper lacustrine unit and great strains are often needed to reach maximum strength. A portion of the problem in determining in-situ strengths may, therefore, be complicated by noncompatible stress-strain characteristics within the design section. In any case, the design of structures founded on the Lake Agassiz deposits must rely at least as heavily on the history of performance as on the values obtained from laboratory testing.

Shear Strength Parameters

There are numerous problems in determining realistic shear strength parameters for the slickensided Lake Agassiz deposits. Experience indicates the use of peak strength as the basis for design would not provide realistic or conservative results. Recent articles in various technical publications have dealt with the stability of slopes in deposits similar to Lake Agassiz deposits. Skempton[3] and others have explored the use of the residual soils strength in investigating the stability of slopes in overconsolidated fissured deposits and have found that failures have often occurred at stresses that approach but never fall below the residual strength. No residual strength tests have ever been performed in these deposits, though work softened strength were utilized in the Pembina, North Dakota, project. No shear strength testing was accomplished for this project, but will be accomplished in phase II studies

to provide a basis for soil strength parameters used for this study.

The lacustrine nature of deposits found in the Red River Valley suggests that samples from the same strata at different locations should have similar properties. This has been shown to be true for Lake Agassiz deposits in studies done by J. F. Rominger [2] P. C. Rutledge and Hibbert Hill*. In this same study, shear strengths were determined on the estimated location of failure planes at various locations in the Lake Agassiz region. They found in-situ strengths to be as low as 300 psf. In our own work we have back-calculated shear strengths along existing shear planes at Oslo, Minnesota (located by visual observation and slope indicators), and found comparable results. Using the same section where failure has occurred and assuming homogeneous properties within each unit results in minimum calculated factors of safety on arcs located much landward of observed failure planes (usually extending beyond the meander belt), and high shear strengths required for equilibrium. This indicates a considerable variation in strength with the history of disturbance as the materials within the meander belt are laced with old slides formed when the river cut into the old lake bed. Back-calculations were performed on four sections from various locations in the Lake Agassiz region. This was accomplished by assuming a range of shear strengths for the upper lacustrine unit and adjusting the strength of the lower lacustrine unit until unity was reached. No attempt to follow the true failure surface was made and homogeneity within each unit was assumed. The result was a strength relationship, shown on plate K-8. The resultant strengths represent in-situ strengths weighted for the effects of disturbance (work softening), incompatible strains and other effects hypothesized and unknown.

It is this chart with the data presented on plate K-7 that was used to choose a design strength of 875 psf for the upper laucstrine unit and 450 psf for the lower lacustrine unit at West Fargo.

Stability Analysis

Slope instability in Lake Agassiz deposits is generally slow to develop and slopes display noticeable cracking before generally modest displacements. Movement most often occurs during construction or in the late summer and early fall. Riverbank and diversion channels are most stable during high water.

Slope stability for the West Fargo diversion channel was analyzed using a computer program applying the modified Swedish method as presented in EM 1110-2-1902, 1 April 1970. The end of construction condition was evaluated. The impervious nature of soils in the area and slow recession of floods minimizes any chance of failure caused by sudden drawdown.

Stability analysis was performed on a typical section illustrated on plate K-5. The 16-foot maximum cut represents the greatest that may be made and ensure stability (F.S.=1.3) of the berm. During the course of construction various material disposal options were taken into consideration by analysis of the effects of using oversized levees for disposal of excess material. The chart of plate K-5 shows that widening the levees necessitates the use of much wider berms. The geologic column for the critical section was a composite of the three borings. This appeared to be the most pragmatic option at this time. In the detailed study phases more subsurface exploration will be accomplished because the upper lacustrine unit is of higher plasticity and appears more slickensided than at other project locations tested in the Red River Valley (see plate K-7). The unit boundaries were difficult to deter-

mine and it was terminated at elevation 886. No boring at the site extended to till, as a result no lower limit was placed on the lower lacustrine unit. Plate K-6 shows the critical arc, with force polygon and a tabulation of data for the 10-foot levee top width option. The factor of safety against sliding for this arc was computed to be 1.33.

Settlement

The low height of levees will preclude significant settlement resulting from construction of levees. Experience and practice indicates that levees less than 15 feet high founded on the lacustrine soils of Lake Agassiz do not warrant settlement calculations and do not settle significantly. This is caused by the overconsolidated nature of the lacustrine soils. Fluvial soils are less likely to be overconsolidated and are generally found within meander belts where higher barriers are usually needed. Settlement may be a problem in these soils. No borings are located at any proposed site for the closure structures. Very thorough investigations must be made in more detailed studies as it is probable that the closure structures will be founded on fluvial deposits.

Seepage

The impervious foundation soils and the use of impervious levee will preclude seepage under or through the levee or closure structures.

Slope Protection

Most of the diversion channel will be excavated in the in-situ fat clays that have proven to resist erosion at other sites in the region including the existing County Drain 21. The channel sideslopes, berm and levees will be

topsoiled and seeded since these areas will not be subjected to high velocities. Riprap or gabion baskets will be used at the inlet and outlet of the diversion channel where higher turbulence can be expected, and where fluvial deposits may exist.

Foundation Preparation

All trees and large vegatation within the limits of construction would be grubbed and cleared. All natural ground in the cut and fill areas will be stripped to a depth of 6 inches.

Instrumentation

Permanently monumented survey sections will be established on the closure structures and at selected locations on the diversion channel. These will be used to monitor settlement and creep should unexpected or unforeseen events occur.

Sources of Construction Materials

Construction materials for the proposed project consist of impervious fill, concrete aggregate, riprap and bedding. An abundance of impervious fill will be provided by channel excavation of lacustrine and fluvial deposits. Material for riprap, bedding and concrete aggregate must be obtained from glacial moraines, lake-washed till and beach deposits along the margin of former glacial Lake Agassiz. These materials were used in the nearby Fargo-Moorhead flood control project have weathered well in almost 20 years of service.

Future Study

The data available for this study was very limited. For future studies

detailed subsurface exploration will be necessary along the diversion channels and at proposed structure locations. The following is a listing of the geotechnical needs and recommendations for further study:

1. Channel cut-slopes have been a problem on some projects in the Red River Valley. Where silt laminae are prominent, face sloughing problems may require that the side slopes be flattened to 1V on 5H. A careful and detailed investigation of County Drain 21 and projects in the area where cut slopes have and have not been stable is needed to augment information which will be obtained from further soils testing.

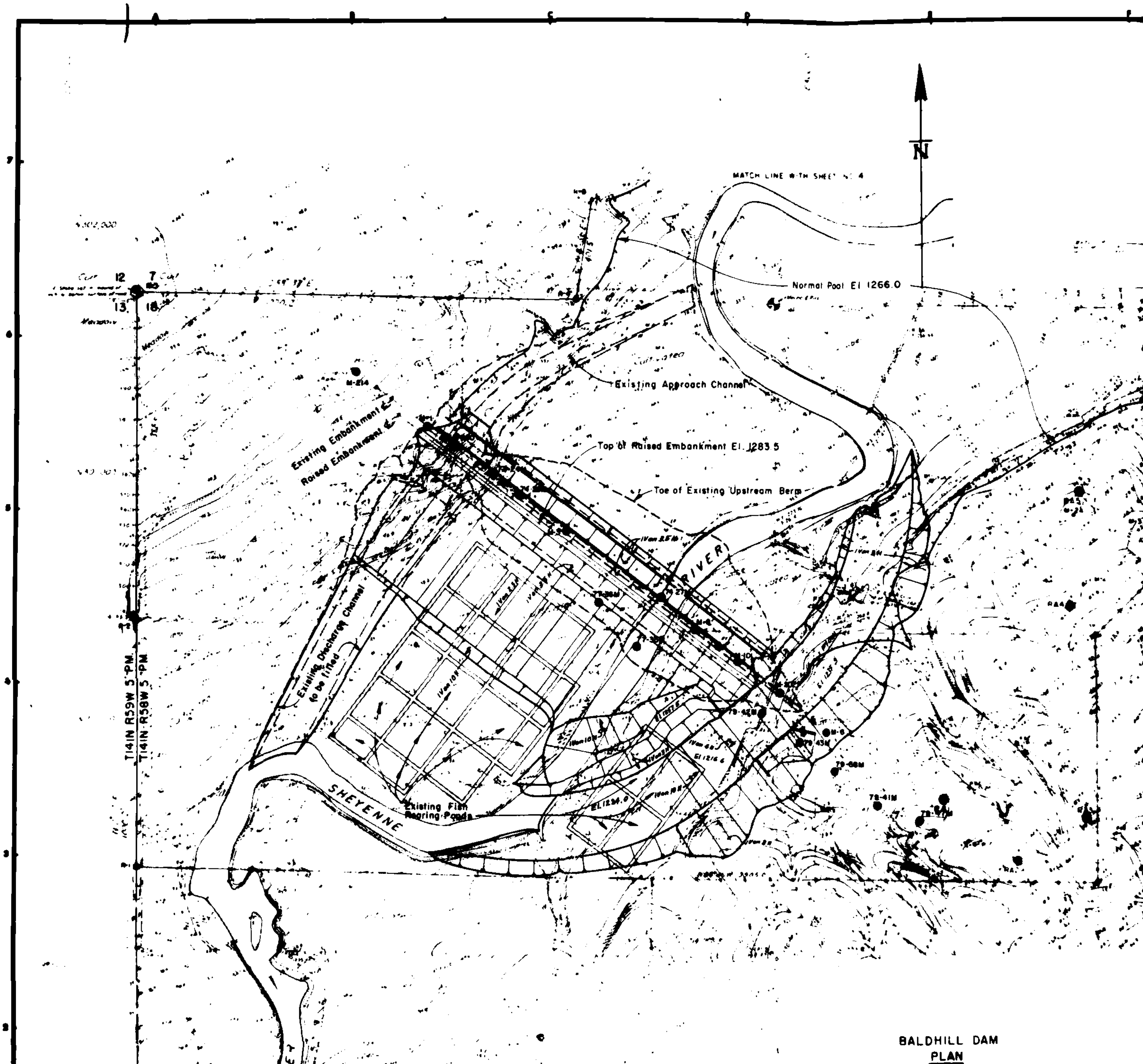
2. The upper lacustrine unit contains more slickensides and has higher Atterberg limits than is common in other parts of the region. Further testing to determine the in-situ mechanical and strength properties of the lower part of this deposit is needed.

3. Because of the size of the project and relative uncertainty of analysis and of cut-slopes in Lake Agassiz clays, consideration should be given to construction and analysis of a full-scale test slope at the site. This may be the only way of taking into account the uncertainties that cannot be uncovered with laboratory testing of these deposits.

1. Hibbert Hill and P.C. Rutledge, unpublished, "Earth Movements in the Red River Valley of the North."

2. J.F. Rominger and P.C. Rutledge, Journal of Geology, V. 60, no. 2, p 160-180, "Use of Soil Mechanics Data in Correlation and Interpretation of Lake Agassiz Sediments."

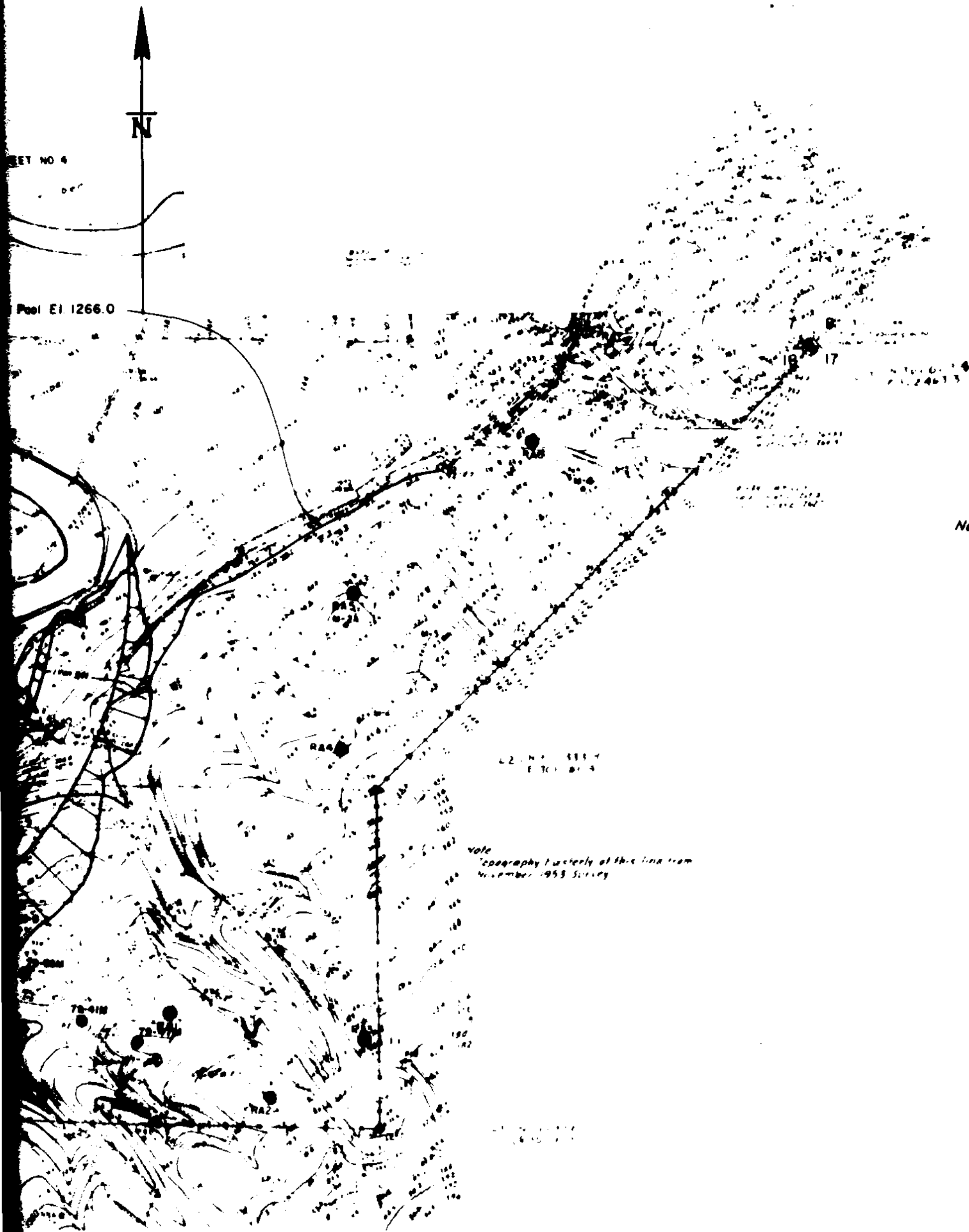
3. A.W. Skempton D. Sc., "Long Term Stability of Clay," Geotechnique 1964. 14:2:77-101.



BALDHILL DAM
PLAN

200 100 0 200 400
Scale (Feet)

2



Notes

1. Topography shown was taken prior to construction of the existing Baldhill Dam.
2. Existing structures and access road on right abutment are not shown. Existing Recreation area on Left Abutment is not shown.
3. Riprap Details not shown

BALDHILL DAM
PLAN

200 100 0 200 400
Scale (Feet)

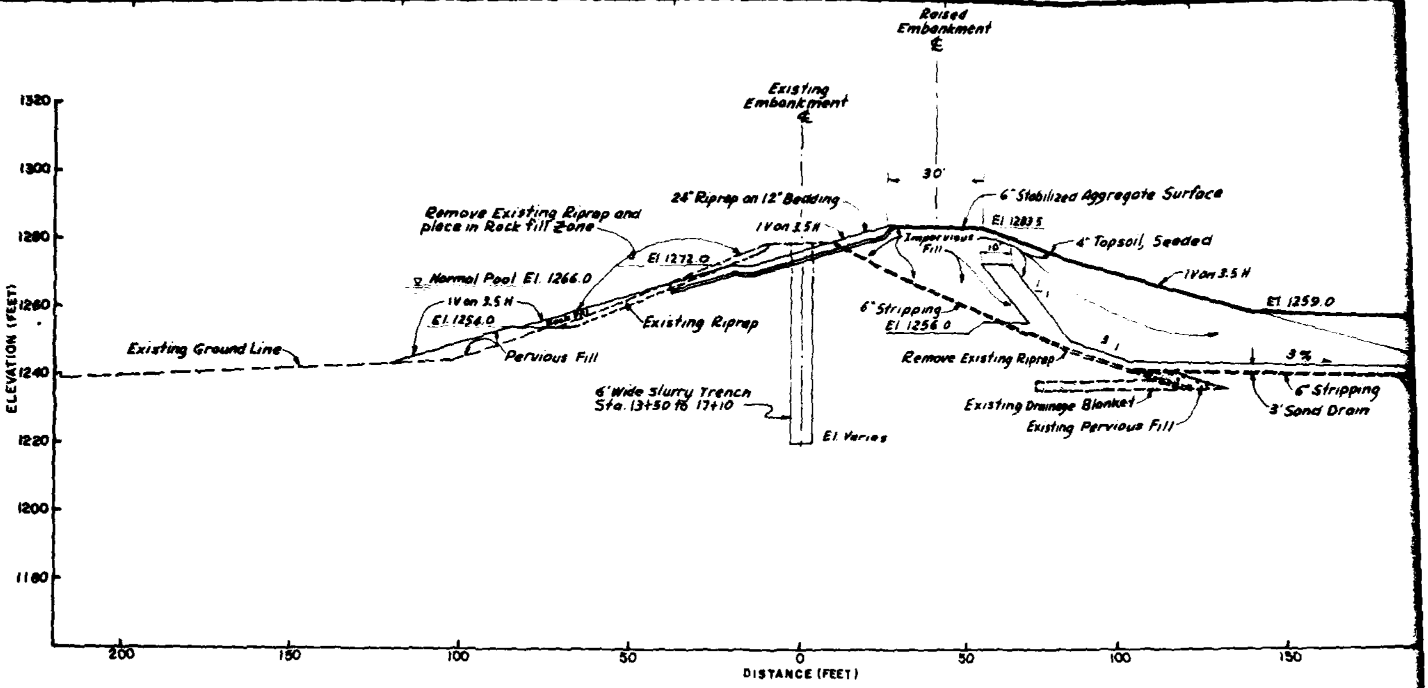
GENERAL DESIGN MEMORANDUM
PHASE I
SHEYENNE RIVER, NORTH DAKOTA
BALDHILL DAM

PLAN AND BORING LOCATIONS

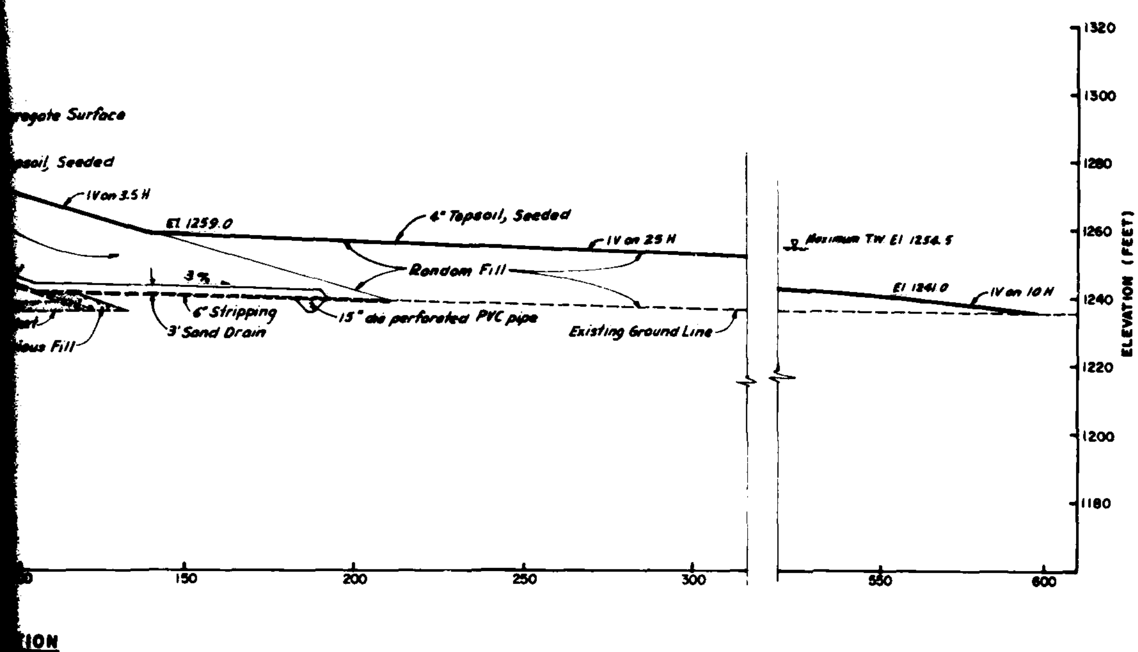
ST PAUL DISTRICT, CORPS OF ENGINEERS

AUGUST 1981

PLATE K-1



TYPICAL EMBANKMENT SECTION

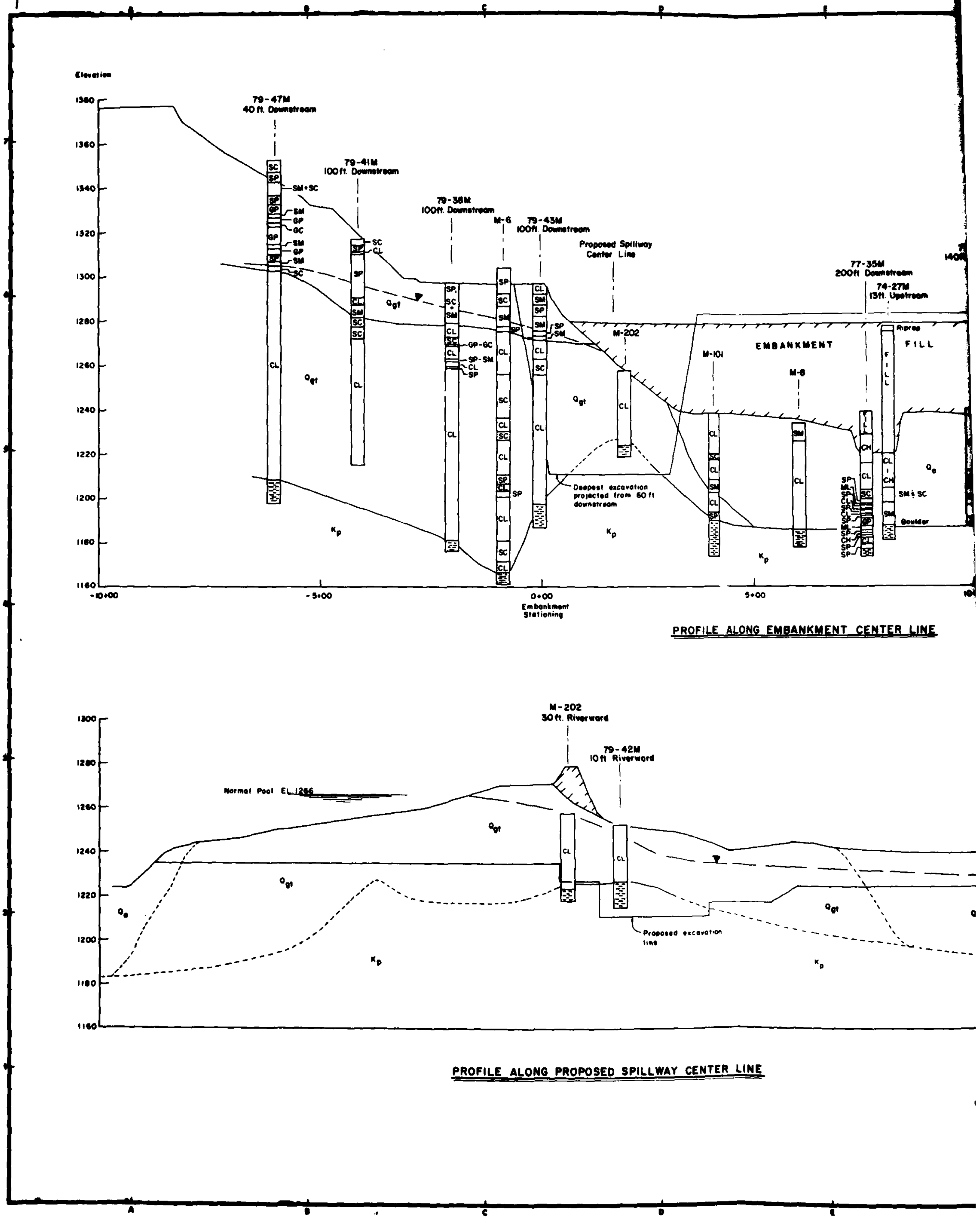


GENERAL DESIGN MEMORANDUM
PHASE I
SHEYENNE RIVER, NORTH DAKOTA
BALDHILL DAM

TYPICAL EMBANKMENT SECTION

ST. PAUL DISTRICT, CORPS OF ENGINEERS

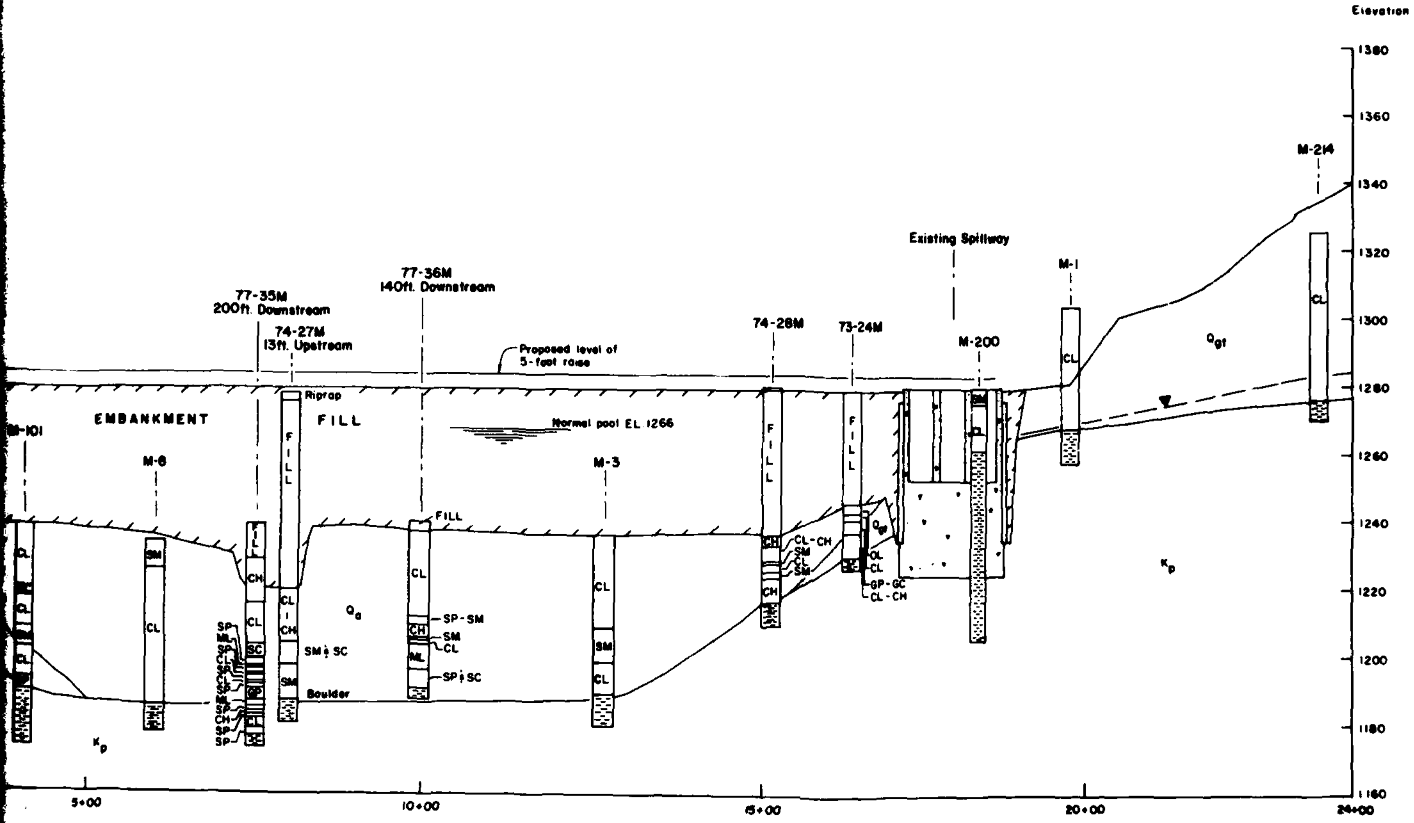
AUGUST 1981



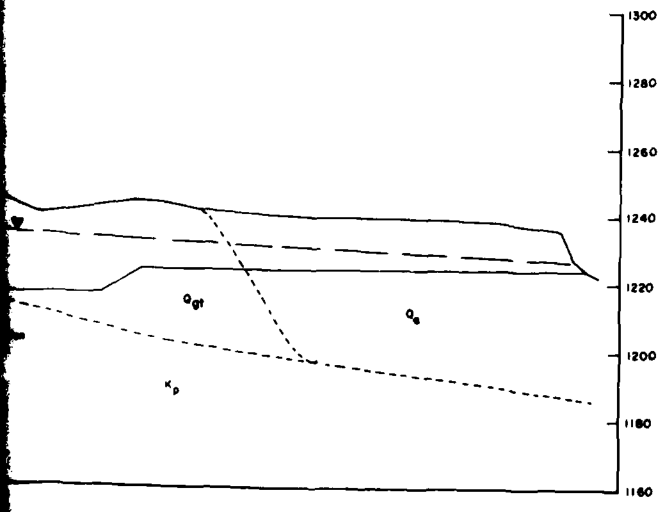
PROFILE ALONG EMBANKMENT CENTER LINE

PROFILE ALONG PROPOSED SPILLWAY CENTER LINE

2



E ALONG EMBANKMENT CENTER LINE



R LINE

0 100 200 300
Horizontal scale in feet

LEGEND

GP	Poorly graded gravels or gravel-sand mix, little or no fines
GC	Clayey gravels, gravel-sand-clay mixtures
SP	Poorly graded sands or gravelly sands, little or no fines
SM	Silty sands, sand-silt mixtures
SC	Clayey sands, sand-clay mixtures
ML	Inorganic silts and very fine sands, silty fine sand with slight plasticity
CL	Inorganic clays, silty, sandy or gravelly clays with low to medium plasticity
OL	Organic silts or clays with low plasticity
CH	Inorganic clays with high plasticity
SM/SC	Borderline material
SC/SM	Stratified material
	Water level in boring
	Shale

Q_{gf} Glaciofluvial deposits composed of stratified mixtures of silt, sand and gravel

Q_{gt} Glacial till composed primarily of gravelly sandy clay with occasional sand strata

Q_a Alluvial fill under the floodplain composed primarily of clay with beds of sand and gravel near the base of the unit

K_p Cretaceous shale comprised of the Gregory and Pembina members of the Pierre Formation

Embankment fill

Approximate location of the water table

Inferred contact

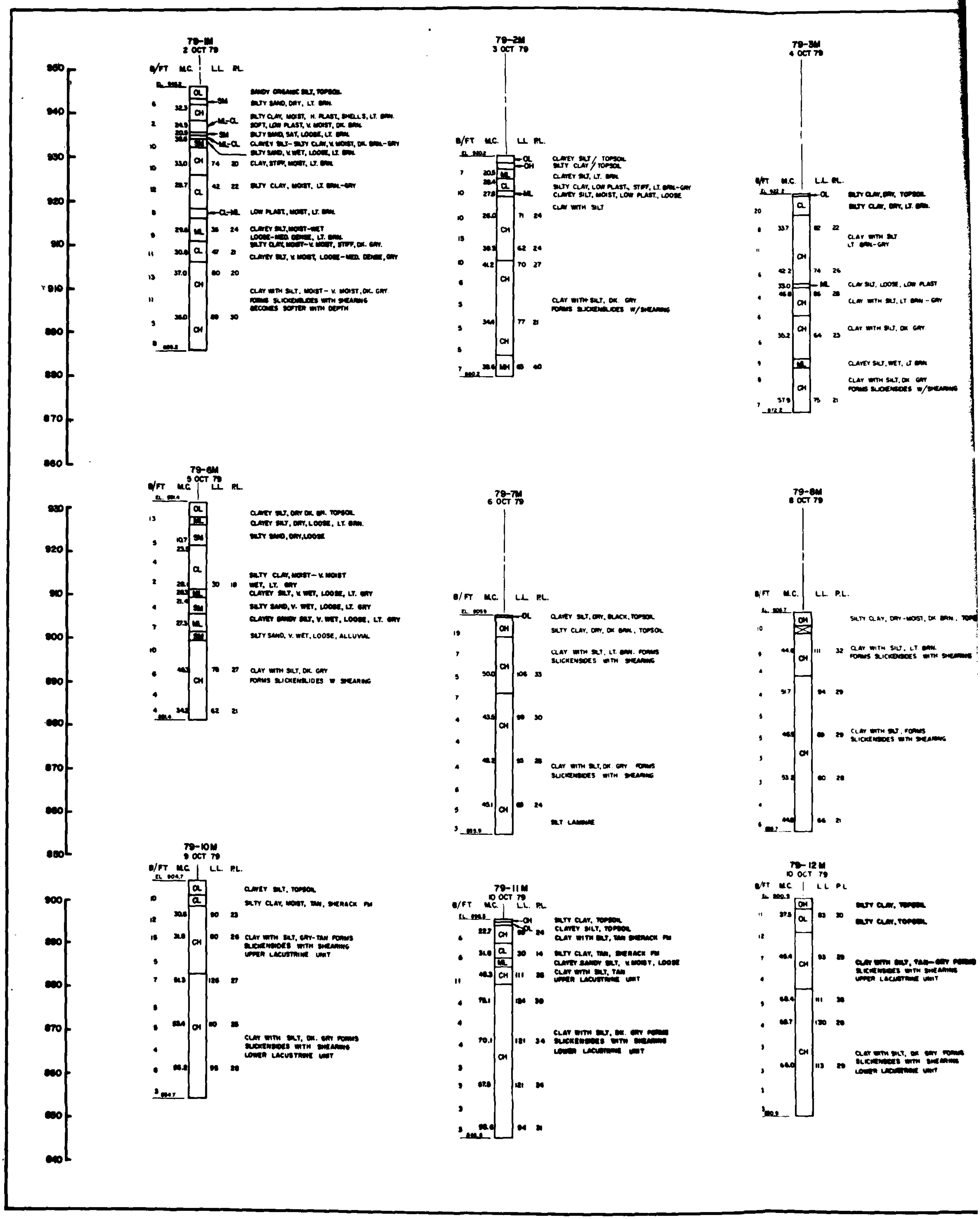
NOTE:

Layout of structures and boring locations shown on plate K-1

GENERAL DESIGN MEMORANDUM
PHASE I
SHEYENNE RIVER, NORTH DAKOTA
BALDHILL DAM
GEOLOGIC PROFILES
EMBANKMENT CENTER LINE
and
PROPOSED SPILLWAY CENTER LINE
ST. PAUL DISTRICT, CORPS OF ENGINEERS

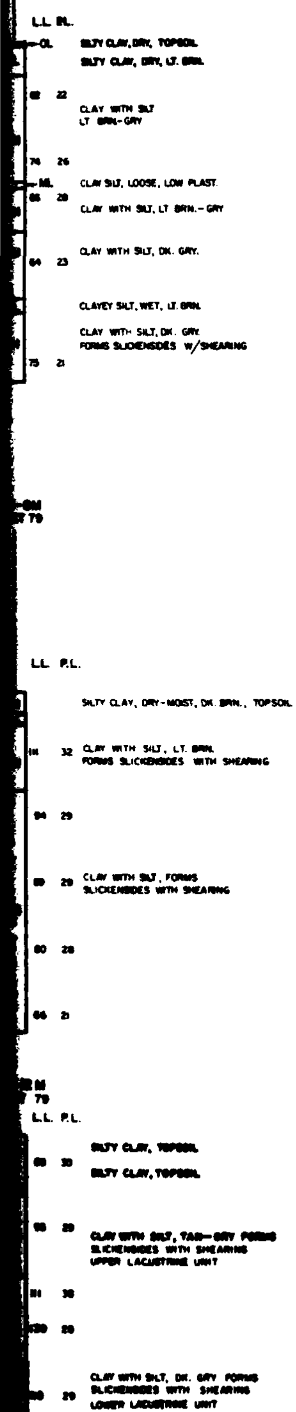
AUGUST 1981

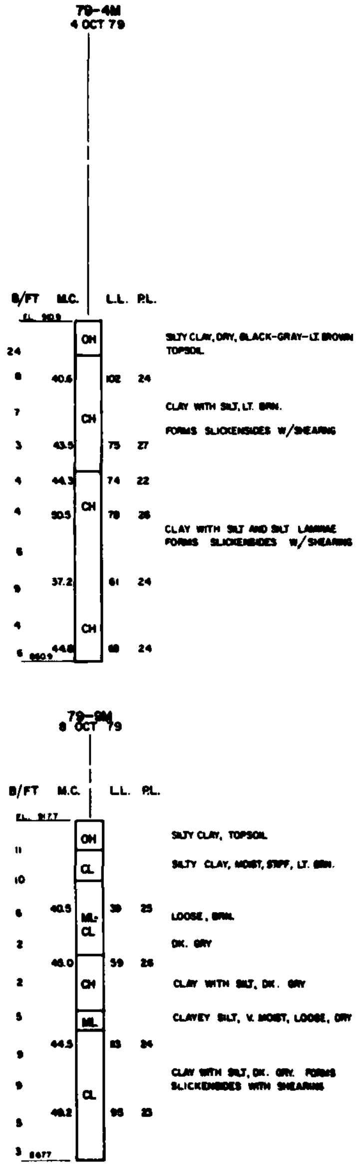
U.S.GPO:1982-564-052/1049-6

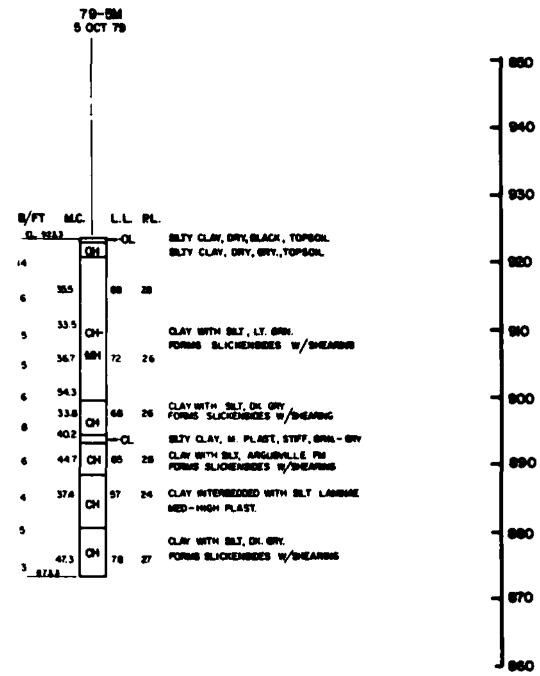


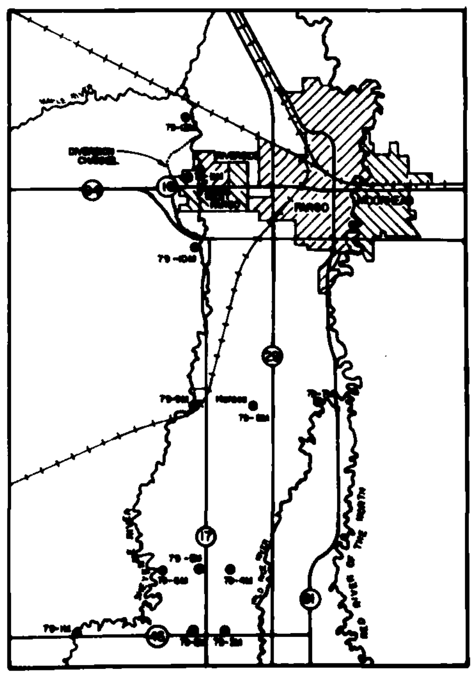
79-1M
2 OCT 79
B/FT M.C. L.L. P.L.
SANDY ORGANIC SILT, TOPSOIL
SILTY SAND, DRY, LT. BRN.
SILTY CLAY, MOIST, H. PLAST, SHELLS, LT. BRN.
SOFT, LOW PLAST, V. MOIST, DK. BRN.
SILTY SAND, SAT, LOOSE, LT. BRN.
CLAYEY SILT- SILTY CLAY, V. MOIST, DK. BRN.-GRY
SILTY SAND, V. WET, LOOSE, LT. BRN.
CLAY, STIFF, MOIST, LT. BRN.
SILTY CLAY, MOIST, LT. BRN.-GRY
LOW PLAST, MOIST, LT. BRN.
CLAYEY SILT, MOIST-WET
LOOSE-MED. DENSE, LT. BRN.
SILTY CLAY, MOIST-V. MOIST, STIFF, DK. GRY.
CLAYEY SILT, V. MOIST, LOOSE-MED. DENSE, GRY
CLAY WITH SILT, MOIST- V. MOIST, DK. GRY
FORMS SLICKENSLIDES WITH SHEARING
BECOMES SOFTER WITH DEPTH
79-2M
3 OCT 79
CLAYEY SILT / TOPSOIL
SILTY CLAY / TOPSOIL
CLAYEY SILT, LT. BRN.
SILTY CLAY, LOW PLAST., STIFF, LT. BRN.-GRY
CLAYEY SILT, MOIST, LOW PLAST., LOOSE
CLAY WITH SILT
CLAY WITH SILT, DK. GRY
FORMS SLICKENSLIDES W/SHEARING
79-3M
4 OCT 79
SILTY CLAY, GRY, TOPSOIL
SILTY CLAY, GRY, LT. BRN.
CLAY WITH SILT
LT. BRN-GRY
CLAY SILT, LOOSE, LOW PLAST
CLAY WITH SILT, LT BRN - GRY
CLAY WITH SILT, DK GRY
CLAYEY SILT, WET, LT BRN
CLAY WITH SILT, DK GRY
FORMS SLICKENSIDES W/SHEARING
79-6M
9 OCT 79
CLAYEY SILT, DRY DK. BR. TOPSOIL
CLAYEY SILT, DRY, LOOSE, LT. BRN.
SILTY SAND, DRY, LOOSE
SILTY CLAY, MOIST- V. MOIST
WET, LT. GRY
CLAYEY SILT, V. WET, LOOSE, LT. GRY
SILTY SAND, V. WET, LOOSE, LT. GRY
CLAYEY SANDY SILT, V. WET, LOOSE, LT. GRY
SILTY SAND, V. WET, LOOSE, ALLUVIAL
CLAY WITH SILT, DK. GRY
FORMS SLICKENSLIDES W SHEARING
79-7M
6 OCT 79
CLAYEY SILT, DRY, BLACK, TOPSOIL
SILTY CLAY, DRY, DK BRN., TOPSOIL
CLAY WITH SILT, LT. BRN. FORMS
SLICKENSIDES WITH SHEARING
CLAY WITH SILT, DK GRY FORMS
SLICKENSIDES WITH SHEARING
SILT LAMINAE
79-8M
8 OCT 79
SILTY CLAY, DRY-MOIST, DK BRN.
CLAY WITH SILT, LT. BRN.
FORMS SLICKENSIDES WITH SHEARING
CLAY WITH SILT, FORMS
SLICKENSIDES WITH SHEARING
79-10M
9 OCT 79
CLAYEY SILT, TOPSOIL
SILTY CLAY, MOIST, TAN, SHERACK FM
CLAY WITH SILT, GRY-TAN FORMS
SLICKENSIDES WITH SHEARING
UPPER LACUSTRINE UNIT
CLAY WITH SILT, DK. GRY FORMS
SLICKENSIDES WITH SHEARING
LOWER LACUSTRINE UNIT
79-11M
10 OCT 79
SILTY CLAY, TOPSOIL
CLAYEY SILT, TOPSOIL
CLAY WITH SILT, TAN SHERACK FM
SILTY CLAY, TAN, SHERACK FM
CLAYEY SANDY SILT, V. MOIST, LOOSE
CLAY WITH SILT, TAN
UPPER LACUSTRINE UNIT
CLAY WITH SILT, DK. GRY FORMS
SLICKENSIDES WITH SHEARING
LOWER LACUSTRINE UNIT
79-12M
10 OCT 79
SILTY CLAY, TOPSOIL
SILTY CLAY, TOPSOIL
CLAY WITH SILT, TAN-GRY FORMS
SLICKENSIDES WITH SHEARING
UPPER LACUSTRINE UNIT
CLAY WITH SILT, DK GRY FORMS
SLICKENSIDES WITH SHEARING
LOWER LACUSTRINE UNIT

2









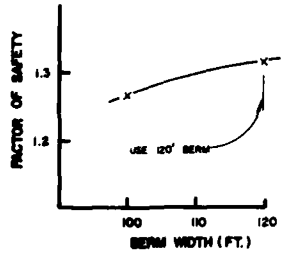
LOCATION MAP

GENERAL DESIGN MEMORANDUM-PHASE I
SHEYENNE RIVER, NORTH DAKOTA

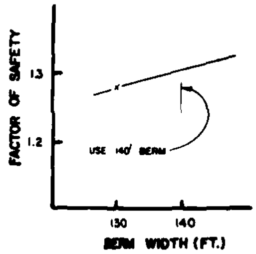
BORING LOGS
FOR DIVERSIONS

U.S. ARMY CORPS OF ENGINEERS

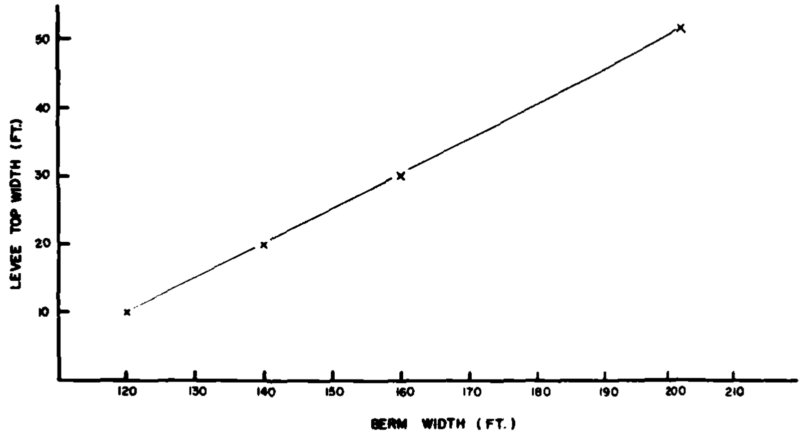
ST. PAUL DISTRICT | PLATE K-4 | SEPTEMBER 1981



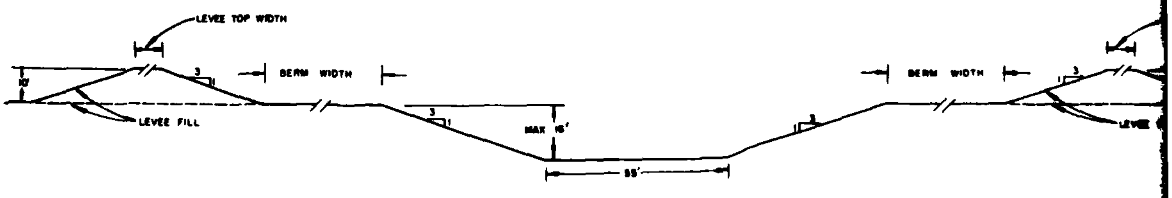
FOR 10 FT. LEVEE TOP



FOR 20 FT. LEVEE TOP

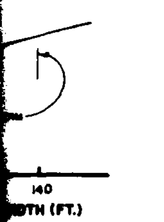


LEVEE / BERM GEOMETRY GRAPH

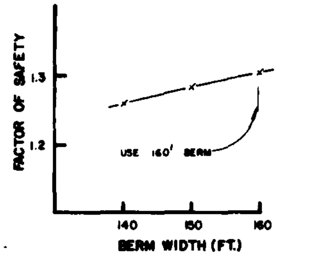


TYPICAL SECTION

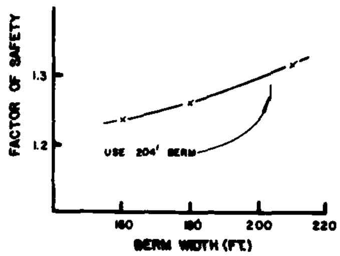
2



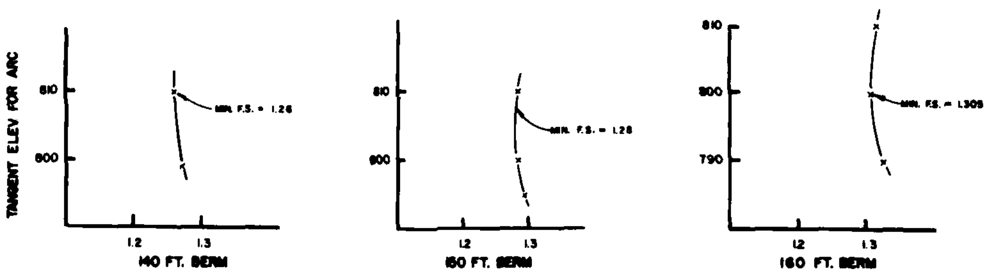
. LEVEE TOP



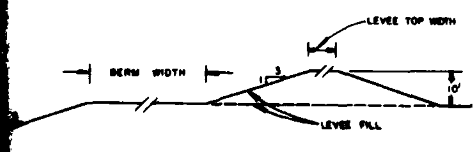
FOR 30 FT. LEVEE TOP



FOR 52 FT. LEVEE TOP



TYPICAL ARC ELEVATION VS. F.S. COMPUTATION (FOR 30 FT. LEVEE TOP WIDTH)

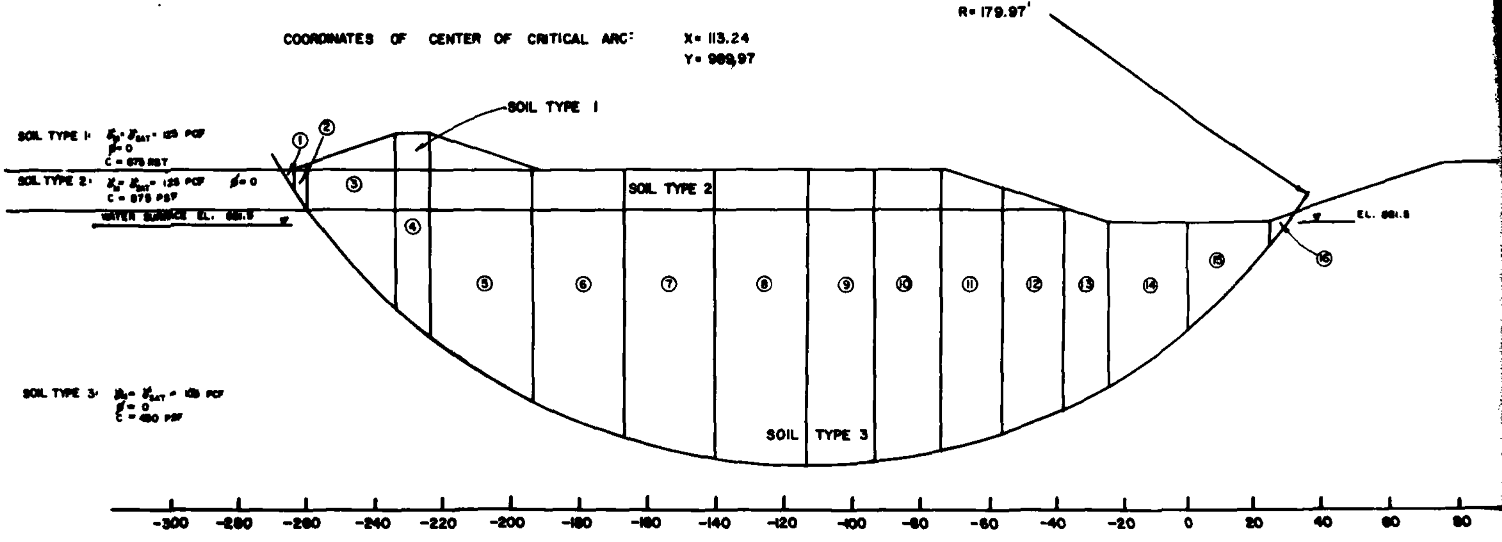


GENERAL DESIGN MEMORANDUM-PHASE I
SHEYENNE RIVER, NORTH DAKOTA

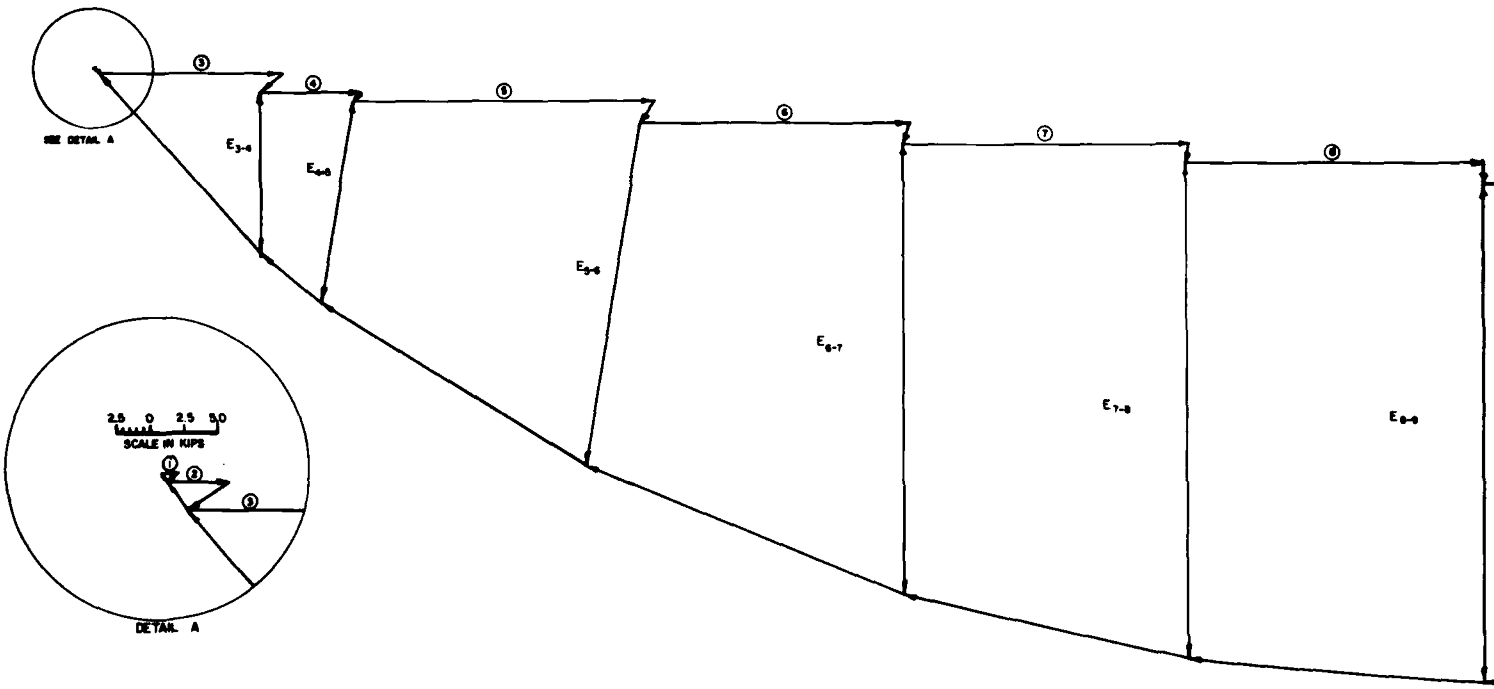
LEVEE/BERM GEOMETRY RELATIONSHIPS
STABILITY ANALYSIS FOR DIVERSION CHANNEL
AT WEST FARGO

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
AUGUST 1981

PLATE K-5



STABILITY SECTION



DETAIL A

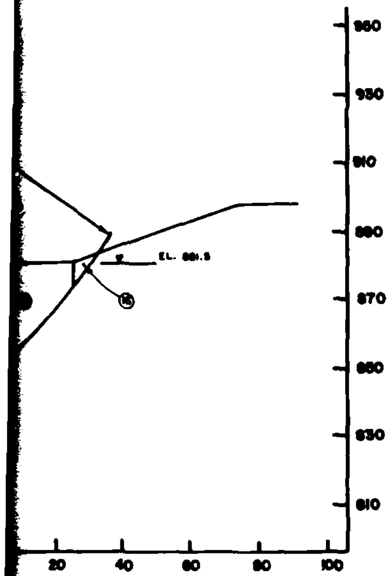
CHECK DATA FOR CRITICAL ARC

FORCE POLYGON FOR CRITICAL ARC

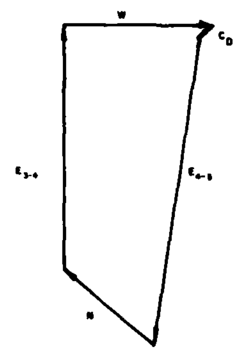
F.S. = 1.336

15 0 15 30

SCALE IN KIPS



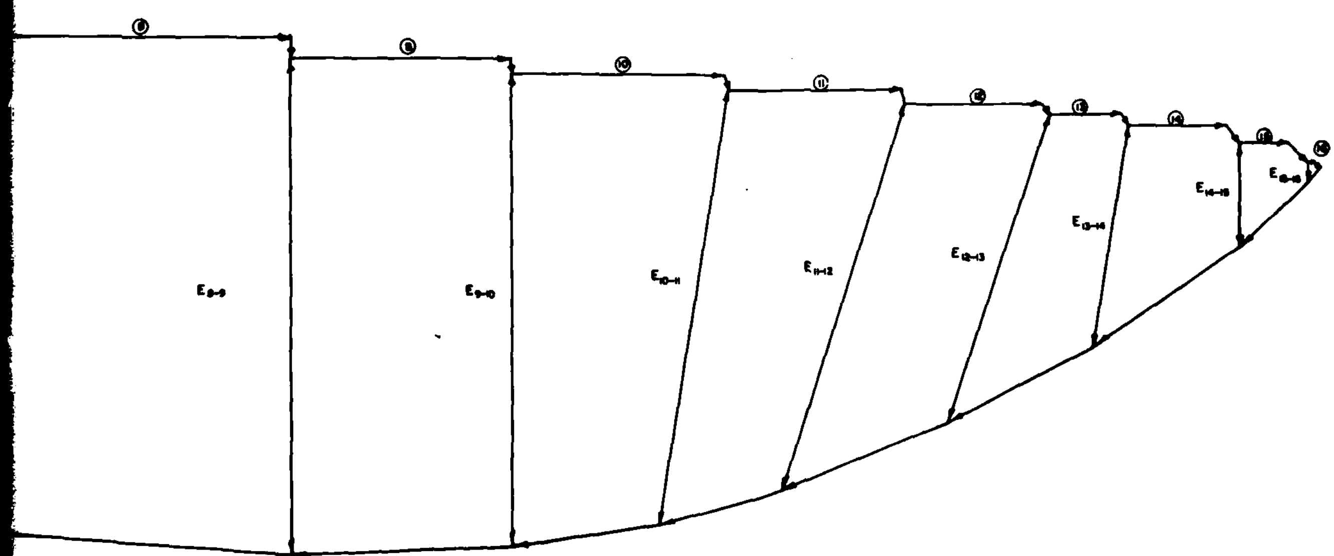
W = RESULTANT WEIGHT
U_R = WATER FORCE
W_T = WEIGHT OF SLICE
C_D = DEVELOPED COHESIVE FORCE
E = SIDE FORCE
F_D = NORMAL FORCE
α_T & α_B = DIRECTION OF SIDE FORCES



W = EFFECTIVE WEIGHT OF SLICE
N = NORMAL FORCE ON BASE OF SLICE
C_D = DEVELOPED COHESIVE FORCE ON BOTTOM OF SLICE

TYPICAL SLICE

10 0 10 20
SCALE IN KIPS
SLICE NO. 4



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GENERAL DESIGN MEMORANDUM-PHASE I
SHEYENNE RIVER, NORTH DAKOTA

CRITICAL ARC/FORCE POLYGON

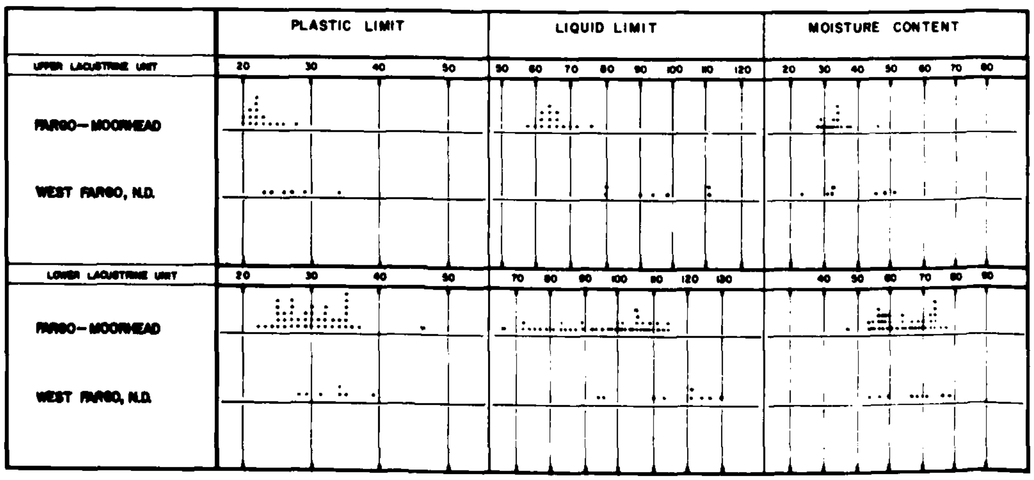
STABILITY ANALYSIS FOR DIVERSION CHANNEL AT WEST FARGO

U.S. ARMY CORPS OF ENGINEERS

ST. PAUL DISTRICT | PLATE K-6 | AUGUST 1981

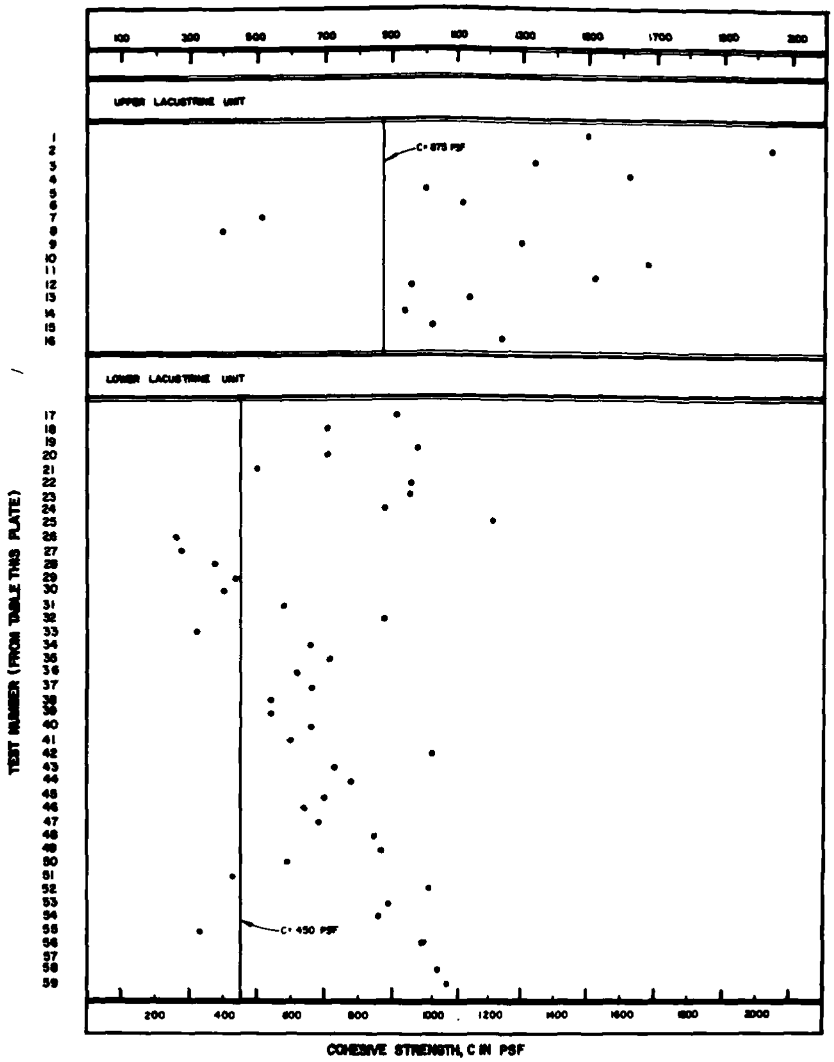
UNIT (TEST NO.)	BORING NO.	SAMPLE NO.	ELEVATION	TYPE TEST	L.L.	P.L.	MOISTURE CONTENT	SPECIFIC GRAVITY	DRY DENSITY	INITIAL e	CLASSIFICATION	C psf	SLICKENSIDED
UPPER LACUSTRINE UNIT													
1	M104	P-3	879.0	UC	64.4	21.3	29.2	2.71	94.1	.80	CH	1500	NO
2		P-4	876.9	UC	65.9	27.7	28.9	2.78	93.3	.86	CH	2040	NO
3		P-5	875.7	UC	67.4	22.4	31.6	2.69	90.2	.86	CH	1340	YES
4		P-7	872.3	UC	60.9	21.6	30.5	2.73	92.5	.86	CH	1620	NO
5		P-8	870.2	T	70.4	25.7	28.0	2.78	92.8	.93	CH	1000	YES
6		P-9	868.9	UC	75.4	25.3	46.4	2.68	79.2	1.09	CH	1120	YES
7	M108	1-S	873.8	UC	61.9	23.4	37.4	2.71	80.3	1.11	CH	520	NO
8		3-S	868.8	UC	68.0	22.5	37.8	2.72	82.4	1.08	CH	400	NO
9	M109	1-S	876.2	UU	61.9	20.4	30.1	2.72	84.5		CH	1300	NO
10		3-S	873.5	UC	66.8	24.1	33.4	2.65	88.1		CH	1680	NO
11		5-S	869.5	UC	64.8	20.1	34.0	2.75	87.6		CH	1520	NO
12		7-S	865.5	UC	58.4	22.1	34.4	2.65	85.9		CH	980	NO
13		9-S	861.5	UC	66.9	21.3	34.1	2.70	87.2		CH	1140	NO
14		11-S	857.5	UC	62.9	21.2	33.9	2.71	89.6		CH	940	NO
15		13-S	853.5	UC	72.3	22.0	35.2	2.68	81.3		CH	1020	NO
16		15-S	849.5	UC	63.8	21.6	33.1	2.70	90.0		CH	1240	NO
LOWER LACUSTRINE UNIT													
17	M104	P-10	866.4	UC	110.9	46.3	55.9	2.78	65.4	1.64	CH	920	YES
18		P-11	864.9	UC	107.0	29.1	56.6	2.68	69.7	1.38	CH	700	YES
19		P-17	860.1	UC	102.7	27.1	65.1	2.63	60.7	1.71	CH	980	YES
20		P-19	846.2	UC	100.2	25.2	71.8	2.68	56.5	1.97	CH	700	YES
21	M106	9-S	853.0	UC	104.5	33.7	71.9	2.64	58.3		CH	500	YES
22		13-S	845.0	UC	100.8	31.2	69.0	2.69	58.5		CH	980	YES
23		16-S	841.0	UC	92.5	27.1	61.5	2.70	65.3		CH	955	YES
24		21-S	829.0	UC	74.0	25.7	52.8	2.68	70.1		CH	880	YES
25		28-S	821.0	UC	72.2	24.4	47.2	2.65	75.0		CH	210	YES
26	M108	7-S	858.0	UC	113.2	27.7	67.6	2.77	62.7	1.73	CH	280	YES
27		8-S	852.5	T	114.2	36.6	70.1	2.78	57.4	2.03	CH	280	YES
28		9-S	851.0	UC	102.0	26.1	72.5	2.70	60.0	1.82	CH	380	YES
29		10-S	848.4	UC	108.0	33.8	72.8	2.78	55.9	2.10	CH	440	YES
30		11-S	847.0	UC	104.9	26.7	71.8	2.67	57.7	1.89	CH	400	YES
31		12-S	845.0	T	90.0	32.2	62.9	2.78	61.9	1.80	CH	580	YES
32		13-S	843.0	UC	92.1	28.1	53.9	2.70	67.7	1.49	CH	880	YES
33		5-S	858.5	UC	98.4	25.2	77.6	2.68	58.2	2.03	CH	320	YES
34		14-S	835.8	UC	75.0	31.8	57.6	2.78	65.4	1.65	CH	680	YES
35		15-S	834.0	UC	80.8	23.9	57.2	2.66	67.9	1.45	CH	720	YES
36		16-S	832.0	T	83.2	29.0	55.5	2.78	66.4	1.61	CH	620	YES
37		17-S	830.0	UC	77.4	22.0	56.4	2.66	68.3	1.43	CH	880	YES
38	M109	17-S	845.5	UC	105.1	27.2	63.8	2.70	62.3		CH	540	YES
39		19-S	841.5	UC	79.3	24.9	57.0	2.67	62.0		CH	540	YES
40		21-S	837.5	UC	66.3	22.9	59.4	2.73	68.9		CH	660	YES
41	M111	11-P	848.7	UC	[illegible]	35.1	67.4	2.68	61.2		CH	600	YES
42		12-S	848.1	T	114.3	34.8	67.7	2.78	59.0	1.94	CH	1020	YES
43		15-S	842.2	UC	108.2	35.1	68.8	2.67	59.9		CH	730	YES
44		19-S	834.2	UC	72.2	26.9	56.3	2.69	68.8		CH	780	YES
45		20-S	832.2	T	89.0	32.3	53.9	2.78	67.8	1.56	CH	700	YES
46	M113	11-S	858.1	UC	104.8	30.5	52.7	2.07	63.2		CH	640	YES
47		17-S	845.7	UC	98.4	29.8	63.0	2.72	63.3		CH	880	YES
48		18-S	842.2	UC	96.0	25.2	59.4	2.72	65.3		CH	850	YES
49	M114	11-S	861.5	UC	100.4	27.8	63.4	2.69	64.1		CH	670	YES
50	M116	11-S	843.3	UC	111.4	34.6	75.0	2.80	57.3		CH	580	YES
51		15-S	836.4	UC	84.1	33.3	59.4	2.69	59.4		CH	430	YES
52		18-S	827.4	UC	85.0	28.6	58.2	2.80	58.2		CH	1010	YES
53		23-S	819.4	UC	87.1	31.9	59.5	2.65	59.5		CH	880	YES
54	M117	9-S	863.6	UC	108.6	34.7	73.1	2.68	57.7		CH	880	YES
55		11-S	858.9	UC	110.2	32.8	73.0	2.80	58.4		CH	330	YES
56		15-S	851.0	UC	108.9	34.5	73.4	2.82	55.9		CH	880	YES
57		21-S	838.0	UC	101.4	30.9	57.7	2.82	65.8		CH	440	YES
58	M118	9-S	861.9	UC	107.4	29.5	64.1	2.81	61.0		CH	1170	YES
59		13-S	853.9	UC	97.1	35.0	65.5	2.80	60.0		CH	1080	YES

LABORATORY TEST DATA FROM FARGO-MOORHEAD



COMPARISON OF TEST DATA, WEST FARGO VS. FARGO-MOORHEAD

2



SHEAR TEST DATA

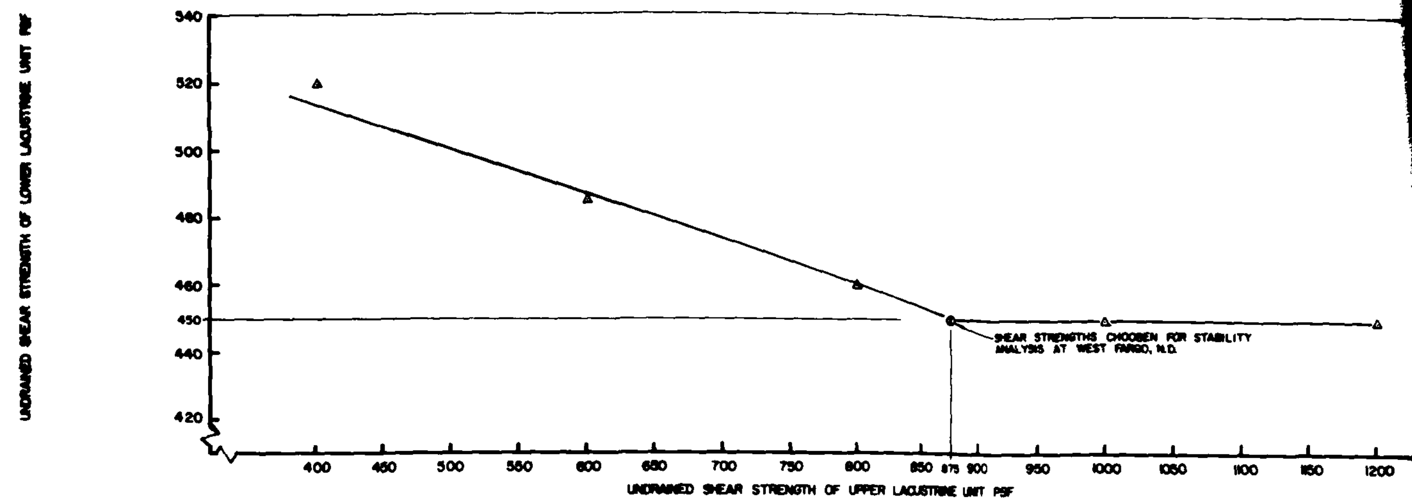
FARGO, N.D. — MOORHEAD, MN.

GENERAL DESIGN MEMORANDUM - PHASE I
SHEYENNE RIVER, NORTH DAKOTA

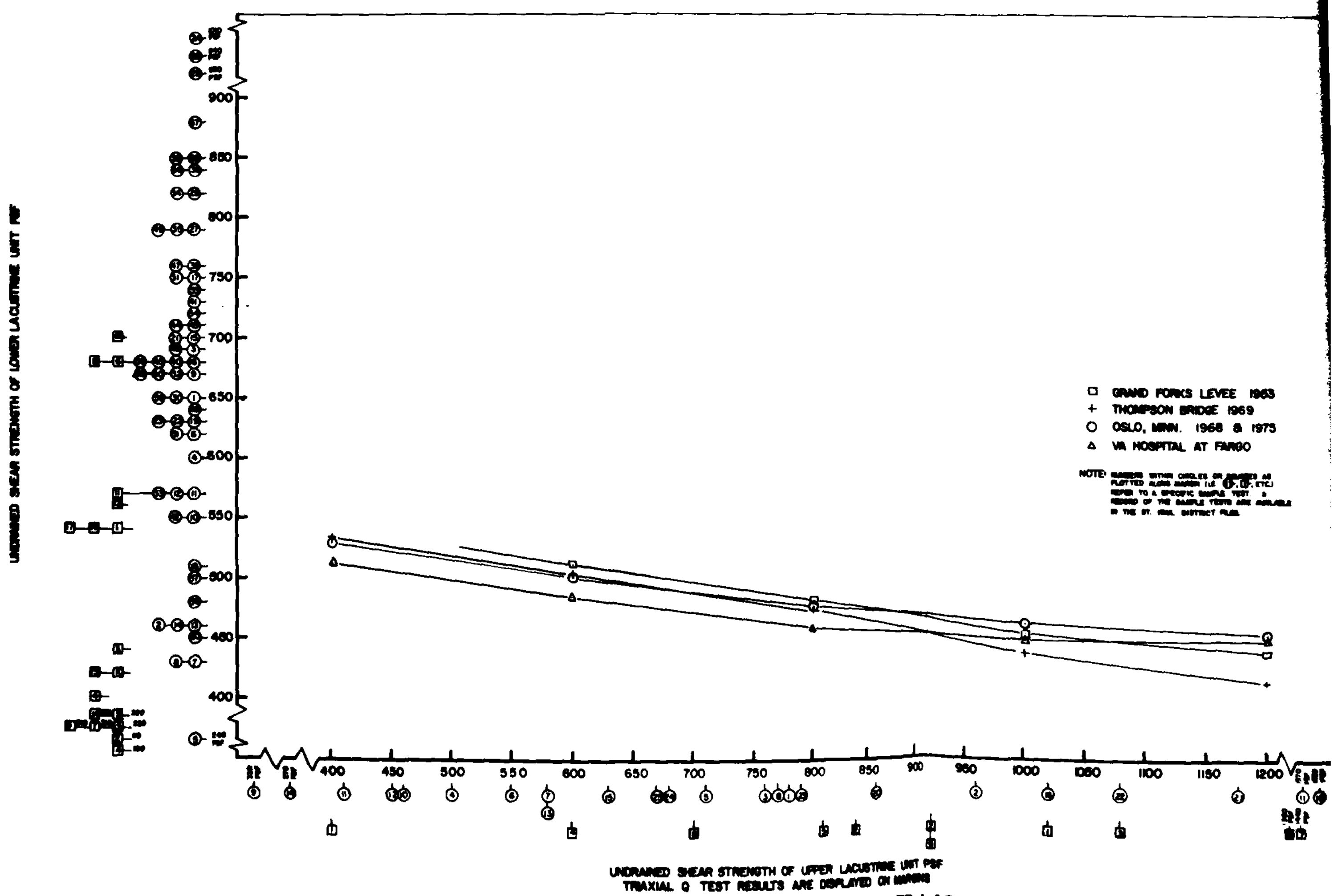
STRENGTH CHARACTERISTICS - LAKE AGASSIZ DEPOSITS
TEST DATA PARAMETER SELECTION

U.S. ARMY CORPS OF ENGINEERS

ST. PAUL DISTRICT | PLATE K-7 | SEPTEMBER 1981



RELATIONSHIP BETWEEN UNDRAINED STRENGTHS OF UPPER AND LOWER LACUSTRINE UNITS AT FARGO FOR F.S. = 1.0



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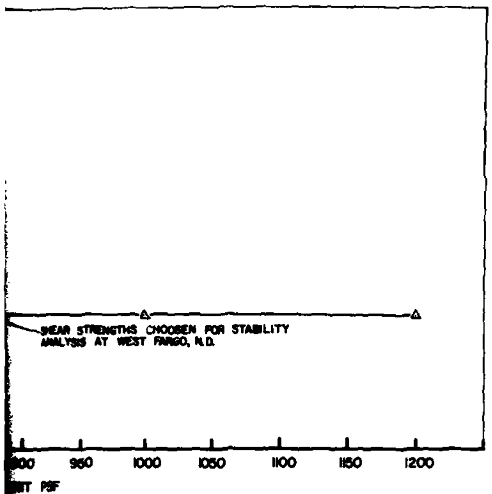
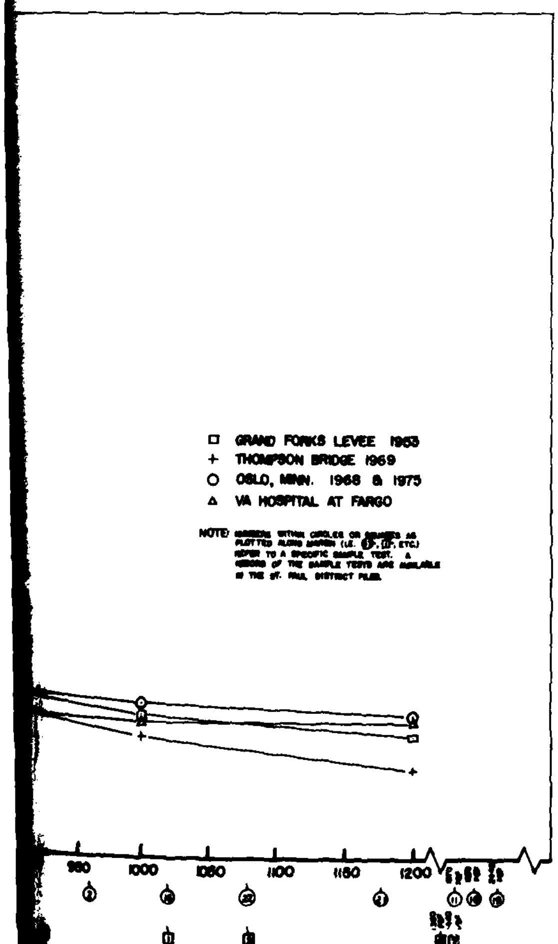


LACUSTRINE UNITS AT FARGO FOR F.S. = 1.O

	THICKNESS OF FILL FT.	THICKNESS OF UPPER LACUSTRINE UNIT FT.	THICKNESS OF LOWER LACUSTRINE UNIT FT.	DEPTH TO TILL FT.
GRAND FORKS LEVEE	10	28	29	67
THOMPSON BRIDGE	10-22	9-32	9-22	60-6[illegible]
OSLO CLOSURE AREA	—	46	59	106
V.A. HOSPITAL AT FARGO	12	18	68	98

FOUNDATION COMPOSITION BELOW FILL



...CUSTRINE UNITS FOR F.S. = 1.O

GENERAL DESIGN MEMORANDUM - PHASE I
SHEYENNE RIVER, NORTH DAKOTA

STRENGTH CHARACTERISTICS
OF LAKE AGASSIZ DEPOSITS

U.S. ARMY CORPS OF ENGINEERS

ST. PAUL DISTRICT | PLATE K-8 | SEPTEMBER 1981

APPENDIX L

FLOOD DAMAGE REDUCTION ALTERNATIVES

GENERAL REEVALUATION

AND

ENVIRONMENTAL IMPACT STATEMENT

SHEYENNE RIVER, NORTH DAKOTA

AUGUST 1982

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APPENDIX L

FLOOD DAMAGE REDUCTION ALTERNATIVES

INTRODUCTION

The flood damage reduction alternatives presented in this appendix constitute all of the basic alternatives evaluated for reducing flood damages in the Sheyenne River basin. The alternatives are measures which, at appropriate levels of development and in appropriate combinations, might provide workable plans. The list of alternatives was developed from past studies of the Sheyenne River completed by Federal and State interests, public meetings and workshops which discussed the flooding problems, and current evaluations of flood problems. The alternatives are presented in two general classifications: those considered but dropped and those considered appropriate for implementation.

The detailed description and data concerning each alternative are included: however, the combination of the alternatives and the rationale for keeping or dropping each alternative are found in Appendix M, Plan Formulation.

The information presented is based on each alternative working independently and is meant to indicate where the alternative would be effective and how effective it would be compared with the other alternatives. However, the overall effectiveness of an alternative can be measured only when that alternative is considered as part of a plan. The plans are discussed in Appendix M, Plan Formulation. For identification purposes, the locations of diversions, dams, and other alternatives are listed by river mile above the mouth. For example, Cooperstown Dam is listed as M-320, which indicates it is located at river mile 320 on the main stem of the Sheyenne River. For tributary dams, the location

of the tributary is given, as in Spring Coulee Dam T-393, which indicates that the dam is located on the Spring Coulee and that Spring Coulee joins the Sheyenne River 393 river miles above its mouth.

ALTERNATIVES DROPPED AT THE FIRST CUT

The alternatives presented in this section were considered at the initial level of evaluation but were dropped during the first cut of alternatives in February 1978. The data and information compiled are preliminary. The costs and benefits are at October 1977 levels. If the costs and/or benefits for these alternatives are to be compared with those for alternatives presented elsewhere in the report, the figures should be updated to a comparable price level.

LEVEES

Valley City

This alternative would consist of intermittent levees and floodwalls flanking the Sheyenne River through Valley City. The levees and floodwalls would be on both sides of the river and would be designed to protect from the 1-percent chance flood with 3 feet of freeboard. About 2 miles of concrete floodwall and 3 miles of earthen levee would be required, as well as interior drainage facilities, raising and/or replacing bridges, and relocating streets and utilities. The first cost of $15 to $25 million with the total average annual benefits of $800,000 resulted in a benefit-cost ratio of 0.5. This alternative would reduce total flood damages at Valley City by 70 percent.

Lisbon

A levee system would protect Lisbon, North Dakota, from Sheyenne River floods. The earthen levee would be in three sections having a total length of about 2 miles. The main segment would parallel the Sheyenne River on the east as it goes through town. A short section of

floodwall and interior drainage facilities would be required. The levee would be designed to protect from the 1-percent chance flood with 3 feet of freeboard. The first cost of $2 to $4 million and total average annual benefits of $100,000 resulted in a benefit-cost ratio of 0.4. This alternative would reduce total flood damages at Lisbon by 70 percent.

Kindred

A short stretch of levee would be constructed along the west side of the Sheyenne River from about 1 mile upstream of the Highway 46 crossing of the Sheyenne River to about 1 mile downstream. These 2 miles of earthen levee would be designed to contain the 1-percent chance flood with 3 feet of freeboard and prevent overtopping and flooding of Kindred. The first cost was $0.5 to $1.5 million. However, no total average annual benefits could be estimated.

Horace

This alternative would consist of an earthen levee around Horace. The levee would be designed to protect from the 1-percent chance flood with 3 feet of freeboard. About 2 miles of levees, interior drainage, and closure structures would be required at road and railroad crossings. The first cost of $5 to $8 million and the total average annual benefits of $160,000 resulted in a benefit-cost ratio of 0.3. This alternative would reduce flood damages at Horace by about 70 percent.

West Fargo

The three major portions of West Fargo would be protected by earthen levees and floodwalls. One section of levee would protect the main section of town east of the Sheyenne River. The second section would protect that part of the city between the Sheyenne River and County Drain No. 21. The third section would protect that part of the city west of Drain No. 21.

The levee would be designed to protect from the 1-percent chance flood with 3 feet of freeboard. About 13 miles of earthen levee and 1 mile of floodwall would be required, as well as interior drainage facilities, raising and/or replacing of bridges, and closure structures at railroad and highway crossings. The first cost of $15 to $25 million and total average annual benefits of $2,200,000 resulted in a benefit-cost ratio of 1.6. This alternative would reduce total flood damages at West Fargo by 80 percent.

Kindred to Horace

This alternative would consist of levees on both sides of the Sheyenne River from near the Highway 46 crossing of the Sheyenne River to just upstream of Horace. The levees could be located near the river or set back from the river to minimize disruption of the wooded corridor. The total length of levees would be about 32 miles, about 16 miles on each side of the river. The levees would be designed to protect from the 2-percent chance flood without freeboard. The confining effect of the levees in this reach would prevent break-out overflows to the Red River of the North and would send more water into the Horace-West Fargo area raising flood stages in this reach. This effect could become especially pronounced for floods larger than the 2-percent chance flood. For that reason, the levee heights would be limited in this reach. The first cost of $6 to $12 million and total average annual benefits of $250,000 resulted in a benefit-cost ratio of 0.4.

Harwood to the Red River of the North

Levees would be built on both sides of the Sheyenne River from the I-29 crossing of the Sheyenne River to the mouth, including tie-back levees to prevent flooding of the protected area from Harwood Slough, the Red River of the North, and Cass County Drain No. 13. About 26 miles of levees would be involved. The levees would protect from the 1- to 2-percent chance floods with freeboard. These levees would have to be set back

some distance from the riverbank so that they would not significantly affect flood stages upstream or downstream. The first cost of $5 to $10 million and total average annual benefits of $110,000 resulted in a benfit-cost ratio of 0.2.

DIVERSIONS

Sheyenne River

M-19 to RRN (Harwood Slough) - This alternative would consist of a flood diversion channel to protect the lower reaches of the Sheyenne River downstream of the confluence with the Maple River. The channel would start just downstream of the mouth of the Maple River in Section 18 of Reed Township, proceed east and north along the alignment of Harwood Slough, and join the Red River of the North in Section 25 of Harwood Township about 2 miles south of the confluence of the Sheyenne River and the Red River of the North.

The diversion would reduce water surface levels in the Harwood area for floods of a magnitude in excess of about the 10 percent chance flood. The channel would be about 7 miles long and designed to pass about 3,000 cfs (cubic feet per second).

The first cost of $8 to $14 million and total average annual benefits of $100,000 resulted in a benefit-cost ratio of 0.1.

M-33 to RRN - A flood diversion channel would reduce flood stages along the Sheyenne River from about 3 miles south of West Fargo to the Harwood area. The diversion channel would start in Section 29 of Barnes Township about 3 miles south of West Fargo and run east for about 5 miles to Rose Coulee, joining the Red River of the North in Section 36 of Barnes Township about 2 miles south of the I-94 crossing of the Red River of the North.

The channel would be designed to pass about 1,000 cfs, substantially reducing stages up to about 1- to 2-percent chance floods. The diversion would be operated so as not to increase peak flood levels along the Red

River of the North. Generally, this diversion could only be operated during the second flood peak on the Sheyenne River. The first cost of \$4 to \$7 million and total average annual benefits of \$1.6 million resulted in a benefit-cost ratio of 3.8.

M-35 to RRN - A flood diversion channel would reduce flood stages along the Sheyenne River from about 4 miles south of West Fargo to the Harwood area. The diversion channel would start in Section 5 of Stanley Township and follow the alignment of the Sheyenne Diversion to Rose Coulee, joining the Red River of the North in Section 36 of Barnes Township, about 2 miles south of the I-94 crossing of the Red River of the North.

The diversion channel would pass about 2,000 cfs which could substantially reduce stages to about the 1- to 2-percent chance floods. The diversion could be operated so as not to increase peak flood levels along the Red River. Generally, this diversion could only be operated during the second flood peak on the Sheyenne River. The first cost of \$5 to \$8 million and total average annual benefits of \$1.6 million resulted in a benefit-cost ratio of 3.2.

M-138 to Wild Rice River - This alternative would consist of a diversion of floodwaters from the Sheyenne River east of Lisbon to the Wild Rice River west of Wyndmere. Implementation of this diversion requires crossing the drainage divide between the two rivers which is about 40 feet above the level of the Sheyenne River at that point. A dam across the Sheyenne River in conjunction with a gravity flow diversion channel would be required. The dam would be located near Strong Memorial Park (see description of Strong Memorial Park Dam (M-138)). The diversion channel would start in Section 32 of Scoville Township and proceed southeast for about 17 miles to join the Wild Rice River in Section 26 of Hall Township.

The bottom of the flood diversion channel would start at about elevation 1055 near the Sheyenne River and end at an elevation of about 1050 at the Wild Rice River. The channel would be designed to pass about 3,000 cfs. The channel would require excavations up to 35 feet deep.

Effects of the diversion on flood stages along the Red River of the North should be insignificant; however, flood stages along the Wild Rice River could be increased significantly. The first cost of $30 to $35 million and total average annual benefits of $1.5 million resulted in a benefit-cost ratio of 0.5.

<u>M-150 to James River</u> - Floodwaters from the Sheyenne River southeast of Lisbon would be diverted to the Taayer Reservoir in the James River drainage basin. Implementation would require crossing the drainage divide between the two rivers which is about 320 feet above the level of the Sheyenne River at that point. A small, low-head dam across the Sheyenne River, a dam on Dead Colt Creet, a series of pumping stations, and diversion channels would be required. The diversion channel would start in Section 7 of Aliceton Township at the upper end of the Dead Colt Creek Dam (T-150) pool and run about 20 miles southwest to join the Taayer Reservoir about 8 miles east of Oakes.

The amount of water diverted into the Taayer Reservoir would depend on the storage capacity available in the reservoir for each flood. Operation of the diversion would have to be coordinated with the Bureau of Reclamation. The channel and pumps would be sized to handle a flow of 2,000 cfs. The first cost of $60 to $100 million and total average annual benefits of $1.1 million resulted in a benefit-cost ratio of 0.2.

<u>M-155 to James River</u> - Floodwaters from the Sheyenne River south of Lisbon would be diverted to the James River via Bear Creek. Implementation would require crossing the drainage divide between the two rivers which is about 300 feet above the level of the Sheyenne River at that point. A small low-head dam across the Sheyenne River, a series of pumping stations, and diversion channels would be required. The diversion channel would start in Section 26 of Island Park Township and proceed southwest for about 20 miles to Bear Creek.

The channel and pumps would be sized to handle a flow of 2,000 cfs. However, the effects of the diversion on flood stages along Bear Creek and the James River have not been analyzed. The first cost of $60 to $100 million and total average annual benefits of $1.1 million resulted in a benefit-cost ratio of 0.2.

M-190 to James River - This alternative would consist of a diversion from the Sheyenne River at Fort Ransom to the James River via Bear Creek. Implementation would require crossing the drainage divide between the two rivers which is about 220 feet above the level of the Sheyenne River at that point. A low-head dam across the Sheyenne River, a series of pumping stations, and diversion channels would be required. The diversion channel would start in Section 11 of Fort Ransom Township and proceed southwest for about 11 miles to join Bear Creek near Highway 27.

The channel and pumps would be sized to handle a flow of about 2,000 cfs. The effects of this diversion on flood stages along Bear Creek and the James River have not been analyzed. The first cost of $40 to $60 million and total average annual benefits of $1.1 million resulted in a benefit-cost ratio of 0.3.

M-195 to James River - Floodwaters from the Sheyenne River just upstream of Fort Ransom would be diverted to the James River via Bear Creek. Implementation would require crossing the drainage divide between the two rivers which is about 300 feet above the level of the Sheyenne River at that point. A low-head dam across the Sheyenne River and a series of pumping stations and diversions would be required. The diversion channel would start in Section 32 of Northland Township and proceed west for about 3-1/2 miles to join Bear Creek in Section 32 of Northland Township.

The channel and pumps would be sized to handle a flow of about 2,000 cfs. The effects of this diversion on flood stages along Bear Creek and the James River have not been analyzed. The first cost of $30 to $50 million and total average annual benefits of $1.1 million resulted in a benefit-cost ratio of 0.4.

Maple River (M-104) to Sheyenne River

This alternative would consist of a diversion of floodwaters from the Maple River just upstream of Enderlin to the Sheyenne River just upstream of Lisbon. This diversion would cross the drainage divide between the Maple and Sheyenne Rivers which is about 120 feet above the level of the Maple River. The diversion would follow a natural valley between the two rivers. A dam on the Maple River plus a series of pumping stations and channels would be required. The channel could be designed for 2,000 cfs. This diversion would adversely affect flood stages in the Lisbon area and potentially even farther downstream on the Sheyenne River unless it were used in conjunction with other major flood diversions from the Sheyenne River to another river. The first cost was $40 to $80 million. However, no total average annual benefits could be estimated.

CHANNELIZATION: MAPLE RIVER - DURBIN TO MOUTH

This alternative would consist of enlargement and straightening of the Maple River channel from near Durbin at about river mile 32 to the mouth, a total distance of about 19 miles. The length of the river would be shortened about 13 miles by the cutoffs. The channel would be designed to pass about the 5-percent chance flow. One side-channel excavation could be used to minimize environmental and social impacts.

In addition to reduced flood stages along the lower Maple River, the diversion would slightly decrease flood stages along the Sheyenne River between Harwood and West Fargo by reducing the backwater effects of the Maple River. The first cost was $5 to $10 million. However, no total average annual benefits could be estimated.

DAMS

Sheyenne River Main Stem

Highway 18 (M-86) - An earth fill dam would be located at about river mile 86 on the Sheyenne River, about 1 mile west of the Highway 18 crossing of the Sheyenne River in Section 36 of Heneldale Township. The dam would be operated only for flood control, would be about 70 feet high, and would have nearly the maximum storage capacity for the site. The design flood pool elevation would be about 1015 with the top of the dam elevation at about 1025. The flood control storage would be about 190,000 acre-feet. The total area affected by the design flood pool would be about 9,000 acres. About 32,000 acres would be required for purchase in fee title: about 11,000 acres of project lands and 21,000 acres of mitigation lands. The first cost of $35 to $45 million and total average annual benefits of $3.9 million resulted in a benefit-cost ratio of 1.3.

Larson's Bridge (M-110) - This earth fill dam would be located at about river mile 110 on the Sheyenne River, about 5 miles east of Anselm in Section 8 of Owego Township. The dam would be about 65 feet high, have near the maximum storage potential of the site, and be operated for flood control. The design flood pool elevation would be about 1045, with the top of dam elevation at about 1055. The flood control storage would be about 90,000 acre-feet. The total acreage affected by the design flood pool would be about 3,500 acres. About 15,000 acres would be acquired in fee title: about 4,500 acres of project lands and 10,500 acres of mitigation lands. The first cost of $25 to $35 million and total average annual benefits of $2.4 million resulted in a benefit-cost ratio of 1.0.

Strong Memorial Park (M-138) - This earth fill dam would be located at about river mile 138 on the Sheyenne River, about 9 miles east of Lisbon, about 1 mile south of the Highway 27 crossing of the Sheyenne River, and in Section 17 of Scoville Township. The dam would be about 45 feet high,

have near the maximum storage potential of the site, and be operated for flood control. The design flood pool elevation would be about 1065, with the top of dam elevation about 1075. The flood control storage would be about 6,000 acre-feet. The total acreage affected by the design flood pool would be about 1,600 acres. About 6,000 acres would be acquired in fee title: about 2,500 acres of project lands and 3,500 acres of mitigation lands. The first cost would be $4 to $10 million. However, no total average annual benefits could be estimated.

Lisbon (M-171) - This earth fill dam would be located at about river mile 171 on the Sheyenne River, about 5 miles northwest of Lisbon in Section 30 of Tuller Township. The dam would be about 95 feet high and operated for flood control. The design flood pool elevation would be about 1185, with the top of dam elevation about 1195. The flood control storage would be about 330,000 acre-feet. The total acreage affected by the design flood pool would be about 9,400 acres. About 25,000 acres would be acquired in fee title: 8,500 acres of project lands and 11,500 acres of mitigation lands. The maximum potential of the site would allow development of a 220-foot high dam with 3,500,000 acre-feet of storage. However, above elevation 1200, the water impounded by this dam would affect Valley City. The first cost of $60 to $80 million and total average annual benefits of $4.3 million resulted in a benefit-cost ratio of 0.8.

Fort Ransom (M-196) - This earth fill dam would be located at about river mile 196 on the Sheyenne River about 2 miles north of Fort Ransom and in section 36 of Northland Township. The dam would be about 80 feet high and operated for flood control. The design flood pool elevation would be about 1200, with the top of dam elevation about 1210. The flood control storage would be about 180,000 acre-feet. The total area affected by the design flood pool would be about 7,000 acres. About 20,000 acres

would be acquired in fee title: about 8,500 acres of project lands and 11,500 acres of mitigation lands. The maximum potential of the site would allow development of a 220-foot high dam with 3,500,000 acre-feet of storage. However, above elevation 1220, the water impounded by this dam would affect Valley City. The first cost of $50 to $60 million and total average annual benefits of $3.4 million resulted in a benefit-cost ratio of 0.8.

Cooperstown (M-320) - This earth fill dam would be located in Section 13 of Washburn Township at about river mile 320 on the Sheyenne River about 4 miles east of Copperstown and 2 miles north of the Highway 7 crossing of the Sheyenne River. It would be about 60 feet high and operated for flood control. The design flood pool elevation would be about 1340, with the top of dam elevation about 1350. The flood control storage would be 290,000 acre-feet. The total area affected by the design flood pool would be about 14,000 acres. About 34,000 acres would be acquired in fee title: about 17,000 acres of project lands and 17,000 acres of mitigation lands. The maximum potential of the site would allow development of a 150-foot high dam with about 3,000,000 acre-feet of storage. The first cost of $40 to $50 million and total average annual benefits of $3.0 million resulted in a benefit-cost ratio of 0.9.

Warwick (M-418) - This alternative would be an earth fill dam at about river mile 418 on the Sheyenne River about 10 miles southwest of Warwick in Section 32 of Hillsdale Township. The dam would be about 65 feet high and operated for flood control. The design flood pool elevation would be about 1450, with the top of dam elevation about 1460. The flood control storage would be about 280,000 acre-feet. The total area affected by the design flood pool would be about 13,000 acres. About 24,000 acres would be acquired in fee title: about 16,000 acres of project lands and 8,000 acres of mitigation lands. Maximum potential for the site would allow development of an 85-foot high dam with about 620,000 acre-feet of storage. The first cost of $35 to $45 million and total average annual benefits of $1.3 million resulted in a benefit-cost ratio of 0.4.

Sheyenne River Tributary

T-83 - This 60-foot-high earth fill dam would be located on a tributary to the Sheyenne River at about river mile 83. The tributary enters the Sheyenne River from the south just to the east of Highway 18. The dam would be located in Section 32 of Barrie Township.

The top of dam elevation would be about 1040 with the design flood pool elevation about 1030. About 2,900 acre-feet of flood control storage would be available, with the design flood pool affecting about 200 acres. The first cost was $0.4 to $0.8 million. However, only small local benefits near Kindred would result.

T-213 (Spring Creek) - This 80-foot-high earth fill dam would be located on Spring Creek, a tributary to the Sheyenne River at about river mile 213. Spring Creek enters the Sheyenne River from the west near Kathryn. The dam would be located in Section 14 of Oakhill Township, just upstream of Kathryn.

The top of dam elevation would be about 1290, with design flood pool elevation at 1280. About 20,000 acre-feet of flood control storage would be available. The design flood pool would affect about 750 acres. An extensive relocation of railroad track would be required with development of this site. The first cost was $5 to $6 million. Only local benefits near Kindred would result.

T-268 - A 115-foot-high earth fill dam would be located on a tributary to the Sheyenne River at about river mile 268. The tributary enters the Sheyenne River from the west. The dam would be located in Section 14 of Stewart Township about 1 mile southwest of Baldhill Dam.

The top of dam elevation would be about 1375, with the design flood pool elevation about 1365. About 10,000 acre-feet of flood control storage would be available. The design flood pool would affect about 330 acres.

Extensive railroad track relocation would be required with development at this site. The first cost was $4 to $5 million. Only minor benefits near Kindred were estimated.

T-283 (Baldhill Creek) - A 125-foot-high earth fill dam would be located on Baldhill Creek, a tributary to the Sheyenne River and Lake Ashtabula at about river mile 283. Baldhill Creek enters the Sheyenne River and Lake Ashtabula from the west. The dam would be located in Section 5 of Ashtabula Township about 8 miles north of Baldhill Dam.

The top of dam elevation would be about 1355 with the design flood pool elevation about 1345. About 60,000 acre-feet would be available for flood control storage. The design flood pool would affect about 2,200 acres.

This site is the most downstream site; other sites are available at upstream locations with slightly reduced storage capacities and slightly different impacts. The other sites include a site in Section 19 of Sibley Traill Township about 3 miles north of the described site. The first cost was $10 to $15 million with the main flood control benefits realized at Valley City. No benefit-cost ratio was calculated.

T-304 - A 95-foot high earth fill dam would be located on a tributary to the Sheyenne River near river mile 304. This tributary enters the Sheyenne River from the north. The dam would be located in Section 13 of Sverdrup Township near the upper end of Lake Ashtabula and the Griggs and Steele County line.

The top of dam elevation would be about 1375, with the design flood pool elevation about 1365. About 5,000 acre-feet of storage would be available for flood control, with the design flood pool affecting about 180 acres. The first cost was $0.5 to $1.0 million. However, only small local benefits near Valley City would be realized.

T-308 - A 70-foot-high earth fill dam would be located on a tributary to the Sheyenne River near river mile 308. This tributary enters the Sheyenne River from the west. The dam would be located in Sections 8 and 17 of Sverdrup Township about 4 miles southeast of Cooperstown.

The top of dam elevation would be about 1380, with the design flood pool elevation about 1370. About 7,000 acre-feet of storage would be available for flood control. The design flood pool would affect about 350 acres. The first cost was $1.0 to $1.5 million. However, only small local benefits near Valley City would result.

T-321 - This 90-foot-high earth fill dam would be located on a tributary to the Sheyenne River near river mile 321. The tributary enters the Sheyenne River from the east. The dam would be located in Sections 13 and 24 of Washburn Township about 5 miles east of Cooperstown.

The top of dam elevation would be about 1400, with a design flood pool elevation of about 1390. About 7,000 acre-feet of storage would be available for flood control. The design flood pool would affect about 270 acres. The first cost was $0.8 to $1.2 million. Only small local benefits near Valley City would result.

T-334 (Pickerel Lake Creek) - This 45-foot-high earth fill dam would be located on Pickerel Lake Creek, a tributary to the Sheyenne River near river mile 334. The creek enters the Sheyenne River from the northeast. The dam would be located in Section 14 of Romness Township about 8 miles northeast of Cooperstown.

The top of dam elevation would be about 1375, with the design flood pool elevation about 1365. About 9,000 acre-feet of storage would be available for flood control, with the design flood pool affecting about 300 acres. The first cost was $0.8 to $1.6 million. However, only small local benefits near Valley City would be realized.

T-350 (Lake Norway) - A 55-foot-high earth fill dam would be located on a tributary to the Sheyenne River near river mile 350. This tributary flows eastward from Lake Norway and enters the Sheyenne River from the west. The dam would be located in Sections 23 and 26 of Pilot Mound Township about 10 miles south of McVille.

The top of dam elevation would be about 1375, with the design flood pool elevation about 1365. About 10,000 acre-feet of storage would be available for flood control. The design flood pool would affect about 500 acres. The first cost was $1.5 to $2.5 million. However, only small local benefits near Valley City would result.

T-366 (Kloten) - This 90-foot-high earth fill dam would be located on a tributary to the Sheyenne River near river mile 366. The tributary flows into the Sheyenne River from the northeast. The dam would be located in Section 13 of Nesheim Township about 3 miles west of Kloten.

The top of dam elevation would be about 1450, with the design flood pool elevation about 1440. About 4,100 acre-feet of storage would be available for flood control, with the design flood pool affecting about 140 acres. The first cost was $0.8 to $1.5 million. However, only small local benefits near Valley City would result.

T-367 (McVille Coulee) - A 60-foot-high earth fill dam would be located on McVille Coulee, a tributary to the Sheyenne River near river mile 367. McVille Coulee enters the Sheyenne River from the north. The dam would be located in Section 11 of Nesheim Township about 2 miles south of McVille.

The top of dam elevation would be about 1420 with the design flood pool elevation about 1410. About 7,000 acre-feet of storage would be available for flood control, with the design flood pool affecting about 380 acres. The first cost was $0.8 to $1.5 million. Only small local benefits near Valley City would be realized.

T-393 - A 65-foot-high earth fill dam would be located on a tributary to the Sheyenne River near river mile 393. This tributary enters the Sheyenne River from the south. The dam would be located in Section 33 of Dayton Township, about 4 miles southwest of Tolna.

The top of dam elevation would be about 1450 with the design flood pool elevation about 1440. About 900 acre-feet of storage would be available for flood control. The design flood pool would affect about 50 acres. The first cost was $0.4 to $0.6 million. Only very small local benefits at Valley City would result.

T-416 (Robinson Coulee) - A 75-foot-high earth fill dam would be located on Robinson Coulee, a tributary to the Sheyenne River near river mile 416. Robinson Coulee enters the Sheyenne River from the south. The dam would be located in Section 4 of Tiffany Township about 10 miles southwest of Warwick.

The top of dam elevation would be about 1485, with the design flood pool elevation about 1475. About 3,000 acre-feet of storage would be available for flood control, with the design flood pool affecting about 110 acres. The first cost was $0.6 to $1.1 million. Only very small local benefits at Valley City would be realized.

T-438 - This 50-foot-high earth fill dam would be located on a tributary to the Sheyenne River near river mile 438. The tributary enters the Sheyenne River from the northwest. The dam would be located in Section 35 of Oberon Township about 5 miles west of Sheyenne.

The top of dam elevation would be about 1490 with the design flood pool elevation about 1480. About 1,100 acre-feet of storage would be available for flood control. The design flood pool would affect about 80 acres. The first cost was $0.2 to $0.5 million. However, this alternative would not reduce peak flood flows from Valley City downstream.

T-439 - This 50-foot-high earth fill dam would be located on a tributary to the Sheyenne River near river mile 439. The tributary enters the Sheyenne River from the northwest. The dam would be located in Section 3 of Grandfield Township about 5 miles west of Sheyenne and 1 mile south of the Benson-Eddy County line.

The top of dam elevation would be about 1490, with the design flood pool elevation about 1480. About 1,900 acre-feet of storage would be available for flood control, with the design flood pool affecting about 120 acres. The first cost was $0.4 to $0.7 million. However, this alternative would not reduce peak flood flows from Valley City downstream.

T-448 - This 60-foot-high earth fill dam would be located on a tributary to the Sheyenne River near river mile 448. This tributary enters the Sheyenne River from the northeast. The dam would be located in Sections 27 and 34 of West Antelope Township about 10 miles west of Sheyenne.

The top of dam elevation would be about 1500 with the design flood pool elevation about 1490. About 1,500 acre-feet of storage would be available for flood control, with the design flood pool affecting about 80 acres. The first cost was $0.3 to $0.6 million. However, this alternative would not reduce peak flood flows from Valley City downstream.

T-453 (Peterson Coulee) - This 45-foot-high earth fill dam would be located on Peterson Coulee, a tributary to the Sheyenne River near river mile 453. Peterson Coulee enters the Sheyenne River from the northeast. The dam would be located in Section 16 of West Antelope Township about 8 miles southeast of Maddock.

The top of dam elevation would be about 1500 with the design flood pool elevation about 1490. About 2,000 acre-feet of flood control storage would be available, with the design flood pool affecting about 130 acres. The first cost was $0.5 to $0.8 million. However, this alternative would have no effect on peak flood flows from Valley City downstream.

T-460 - A 60-foot-high earth fill dam would be located on a tributary to the Sheyenne River near river mile 460. The tributary enters the Sheyenne River from the north. The dam would be located in Section 17 of South Viking Township about 4 miles south of Maddock.

The top of dam elevation would be about 1530, with the design flood pool elevation about 1520. About 8,000 acre-feet of storage would be available for flood control. The design flood pool would affect about 350 acres. The first cost was $1.2 to $2.0 million. However, this alternative would not affect peak flood flows from Valley City downstream.

T-463 (Big Coulee) - An 80-foot-high earth fill dam would be located on Big Coulee, a tributary to the Sheyenne River near river mile 463. Big Coulee enters the Sheyenne River from the north. The dam would be located in Section 11 of Arne Township about 4 miles southwest of Maddock.

The top of dam elevation would be about 1540 with the design flood pool elevation about 1530. About 19,000 acre-feet of storage would be available for flood control, with the design flood pool affecting about 900 acres. The first cost was $1.5 to $3.0 million. This alternative would have no effect on peak flood flows from Valley City downstream.

T-470 (North Fork) - This 30-foot-high earth fill dam would be located on the North Fork of the Sheyenne River which joins the Sheyenne River at about river mile 470. The dam would be located in Section 23 of East Fork Township about 4 miles northeast of Wellsburg.

The top of dam elevation would be about 1490, with the design flood pool elevation about 1480. About 18,000 acre-feet of storage would be available for flood control, with the design flood pool affecting about 2,200 acres. The first cost was $1.5 to $3.0 million. This alternative would have no effect on peak flood flows from Valley City downstream.

Maple River Main Stem

Watson (M-76) - This 55-foot-high earth fill dam would be located at about river mile 76 on the Maple River about 8 miles northwest of Leonard in Sections 8 and 9 of Watson Township. The top of dam elevation would be

about 1030, with the design flood pool elevation about 1020. About 17,000 acre-feet of storage would be available for flood control, with the design flood pool affecting about 1,600 acres. About 3,800 acres would have to be acquired, including about 2,200 acres of mitigation lands. The first cost was $4 to $8 million. This alternative would have limited effect on flows in the Sheyenne River below the mouth of the Maple River.

Highland (M-87) - A 65-foot-high earth fill dam would be located at about river mile 87 on the Maple River about 7 miles northeast of Enderlin in Section 15 of Highland Township. The top of dam elevation would be about 1065, with the design flood pool elevation about 1055. About 35,000 acre-feet of storage would be available for flood control. The design flood pool would affect about 2,900 acres. About 5,300 acres would have to be acquired, including about 2,400 acres of mitigation lands. The first cost was $0.5 to $2.0 million. This alternative would have limited effects on flows in the Sheyenne River in the Harwood area and on flood stages at West Fargo.

Maple River Tributary

South Branch (T-102) - A 40-foot-high earth fill dam would be located on the South Branch of the Maple River, a tributary to the Maple River at about river mile 102. The South Branch enters the Maple River from the south in Enderlin. The dam would be in Section 9 of Liberty Township about 1 mile south of Enderlin.

The top of dam elevation would be about 1130, with the design flood pool elevation about 1120. About 4,500 acre-feet of flood control storage would be available, with the design flood pool affecting about 400 acres. The first cost was $0.5 to $2.0 million. This alternative would have negligible effect on flows on the Sheyenne River and on flood stages at West Fargo.

T-104a - This 45-foot-high earth fill dam would be located on a tributary to the Maple River at about river mile 104. The tributary enters the Maple River from the west about 1 mile upstream from Enderlin. The dam would be in Section 33 of Pontiac Township about 1 mile northwest of Enderlin.

The top of dam elevation would be about 1145, with the design flood pool elevation about 1135. About 2,800 acre-feet of flood control storage would be available, with the design flood pool affecting about 210 acres. The first cost was $0.5 to $2.0 million. This alternative would have negligible effect on flows on the Sheyenne River and on flood stages at West Fargo.

T-104b - This 40-foot-high earth fill dam would be located on a tributary to the Maple River at about river mile 104. The tributary enters the Maple River from the west about 1 mile upstream of Enderlin. The dam would be in Section 31 of Pontiac Township about 4 miles northwest of Enderlin and 2 miles upstream and west of damsite T-104a.

The top of dam elevation would be about 1180, with the design flood pool elevation about 1170. About 1,800 acre-feet of flood control storage would be available, with the design flood pool affecting about 150 acres. The first cost was $0.5 to $2.0 million. This alternative would have negligible effects on flows on the Sheyenne River and on flood stages at West Fargo.

Lucca (T-110) - A 50-foot-high earth fill dam would be located on a tributary to the Maple River at about river mile 110 on the Maple River. The tributary enters the Maple River from the west. The dam would be in Section 8 of Pontiac Township about 6 miles northwest of Enderlin.

The top of dam elevation would be about 1160, with the design flood pool elevation about 1150. About 6,800 acre-feet of flood control storage would be available, with the design flood pool affecting about 500 acres.

The first cost was $1.0 to $3.0 million. This alternative would have negligible effects on flows on the Sheyenne River and on flood stages at West Fargo.

PROHIBIT REPLACEMENT OF OBSOLETE HOMES IN THE FLOODPLAIN

Prohibiting replacement of obsolete homes in floodplain areas would result in eventual removal of all homes from the floodplain. The process would take a long time because many of the homes have been built fairly recently and would not be considered obsolete for a considerable time. This prohibition would be one type of a floodplain regulation to restrict construction of flood-prone developments. However, a home in the floodplain could be replaced in such a manner that it would not be prone to flood damages. Through use of proper construction techniques and recognition of the damaging flood levels, development could take place in floodplain areas. Such development would be fully consistent with the objective of decreasing future flood damages. Reduction of flood damages need not completely prohibit development in floodplain areas. The type and extent of the floodplain and the characteristics of flooding must be recognized in adopting this type of prohibition.

PUBLIC PURCHASE OF LAND IN THE FLOODPLAIN TO ESTABLISH GREENBELTS

The public purchase of land in the floodplain to establish greenbelts would involve a land purchasing program to ensure public ownership of lands adjacent to rivers. The floodplain lands in the lower Sheyenne River basin are almost completely agricultural. Very little forest cover exists. A narrow band of trees lines each side of the river, and scattered areas of shelterbelts exist. These trees provide an attractive location for residential units. Many of these areas close to West Fargo have already been used for residential development. The trees have been retained, but the nature of the woodland has changed. Many of the residential developments are flood prone and increase the flood damage potential in the area. The small, narrow band of trees along the river helps retain snowfall and moisture

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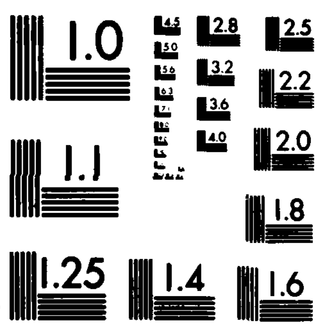

MICROCOPY RESOLUTION TEST CHART
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and reduce erosion; however, it does not have a noticeable effect on flood stages and flood damages within its immediate area. The purchase of these forested areas to preserve them as greenbelts without some form of regulation on building in floodplain areas would have essentially no effect on flood levels or flood damages. Preservation of these lands as greenbelts would provide benefits as recreation corridors, fish and wildlife habitat, and scenic areas. The water management district has some authority over the forested areas adjacent to the streambanks.

ELIMINATION OF FLOOD INSURANCE ON FUTURE CONSTRUCTION

Eliminating the flood insurance program for future buildings in the floodplain would in a sense be a return to past practices. Very few property owners take advantage of the Federally-subsidized insurance program now. Under the current program, owners of new construction are required to purchase flood insurance at actuarial rates which reflect the true cost of the insurance. Because of the high cost of the insurance at actuarial rates, very few people subscribe to the insurance program for new construction. Insurance is not the key element in reducing future flood damages; floodplain regulations are.

EVACUATION OF FLOODPLAIN DEVELOPMENTS

Evacuation of floodplain developments would consist of relocating all structures in the floodplain to nonfloodplain areas. Complete floodplain evacuation is one of the most effective ways to reduce flood damage potential, but it can also result in the most severe impacts on a community. This alternative would involve about 700 homes and 70 businesses in Valley City, 100 homes and 10 businesses in Lisbon, and 1,900 homes and 200 businesses in West Fargo.

FALL RELEASE OF WATER FROM BALDHILL DAM

The current operating plan for Baldhill Dam calls for a uniform release of water from about October to March to draw the pool level down about 3-1/2

feet to provide flood control storage. Releasing most of the water in the fall rather than uniformly throughout the winter might change river ice formation at Valley City, Lisbon, and downstream. However, as long as the pool level of Lake Ashtabula would be sufficiently low by spring runoff, the flood control storage capacity at Baldhill Dam would not be changed and the degree of flood protection provided at Valley City, Lisbon, and other downstream areas would not be changed. The changes expected in ice formation probably would not significantly affect flood damages. Any change of this nature could be evaluated as part of a revised operating plan for Baldhill Dam.

SNAG AND CLEAR MAPLE RIVER - DURBIN TO MOUTH

Snagging and clearing along the lower reaches of the Maple River would have minimal effects on flood stages along the Sheyenne River. Reduction of the debris coming down the Maple River to join the Sheyenne River might help reduce the blocking of bridge openings across the Sheyenne River below the mouth of the Maple River. These blockages and resultant backwater effects would affect the area between the mouth of the Maple River and I-29. Some potential exists to reduce the backwater effects of the railroad crossing near the mouth of the Maple River on flood levels at West Fargo. These potential reductions along the Sheyenne River would be very difficult to quantify.

SNAG AND CLEAR TRIBUTARIES TO THE SHEYENNE RIVER

Snagging and clearing along tributaries to the Sheyenne River would have little effect on flood stages along the Sheyenne River. The amount of debris coming down the river during floods would be reduced but not eliminated. Reduction of debris would lessen flow restrictions through bridges. Extensive snagging and clearing on tributaries could have adverse effects on fish.

ALTERNATIVES DROPPED DURING STAGE 2

The alternatives discussed in this section were retained past the initial screening. However, they were dropped after further evaluation. The information presented is generally more detailed than that presented for the alternatives discussed previously; however, the information is still preliminary. The economic information is at October 1978 price levels.

ALTERNATIVES THAT COULD BE MAJOR COMPONENTS OF FLOOD DAMAGE REDUCTION PLANS

General

The alternatives discussed in this section were carried into stage 2 of the planning process. They were identified as having the potential to significantly reduce flood damages in the basin and they could be used as major components of any comprehensive flood damage reduction plan. However, these alternatives were dropped during or after the stage 2 evaluation process because further study was not warranted. A description of the alternative, including costs, benefits, advantages, and disadvantages, is presented. October 1978 price levels for economic information are given unless otherwise noted.

Diversions to the Wild Rice River

Under certain circumstances, a diversion to the Wild Rice River could be designed to substantially reduce some flood levels along the Sheyenne River. The diversion would have a gated control structure at its inlet on the Sheyenne River and would be operated only when it would not increase the peak flood stages on the Red River of the North. Because the first peak of the Sheyenne River generally coincides with the peak of the Red River at Fargo, the diversion could not be operated during the first peak and would be operated only during the second peak of the Sheyenne River.

Thus, to be considered effective for flood damage reduction, a diversion to the Wild Rice River must be combined with other alternatives that can address the first peak.

Three preliminary designs were evaluated - a 1,000-cfs,2,000-cfs, and 3,000-cfs channel for each of the three locations, M-42, M-54, and M-65. The pertinent information on these designs is shown in table L-1 (page L-34).

These alternatives would have little impact on the environment in comparison with other flood control alternatives. Summaries of the impacts associated with the three diversion alternatives can be found in table L-2 (page L-35).

The surrounding land near each of the diversions is predominantly agricultural, and the land has been classified as prime farmland by the Soil Conservation Service.

The riparian woodlands, which constitute a narrow band along the river, provide habitat for deer and semiaquatic organisms and are a valuable transition area for migrating birds. The woodlands are essential to the wintering deer herds in the lower basin. Loss of the woodland could be mitigated by plantings along the diversion right-of-way. Enhancement opportunities are available through purchase of permanent instead of temporary easements along the diversion and planting of vegetation or windbreaks in these areas. The windbreaks would provide wildlife habitat and could be designed to reduce snow accumulation in the diversion channel.

The noise associated with these diversion alternatives would have minimal effects since the construction would occur in predominantly rural areas. Although ambient noise levels in the area are low, there are few, if any, people in the area who would be bothered by the noise. Following construction, noise levels associated with the operation and maintenance of a diversion would be negligible.

A diversion to the Wild Rice River, aside from offering some protection to West Fargo, would also provide some degree of protection to Horace and the area between Horace and West Fargo. Because a diversion to the Wild Rice River would not be implemented without one of the major flood reduction alternatives as a joint component, the Wild Rice River alternative is not expected to have any net population impacts on West Fargo.

A diversion to the Wild Rice River would have no aesthetic impacts on the Sheyenne River or streambed. It would affect the primarily agricultural areas from the Sheyenne River to the Wild Rice River; however, the banks of excess material from construction of the channel would be unsightly until they were vegetated, and the diversion channel itself would be in visual contrast with the agricultural nature of the area. The diversion to the Wild Rice River would, however, improve the aesthetic setting of the urban environments in Horace and West Fargo by reducing the deposition of silt and debris and damage to structures during floods.

A diversion to the Wild Rice River would have minor beneficial effects on community cohesion. By reducing flood levels from Horace to West Fargo, the diversion would help preserve existing neighborhood structures in presently flood-prone areas. The route of the diversion from the Sheyenne River to the Wild Rice River would not bisect or isolate any existing neighborhoods. It is not expected that any intergroup conflicts would arise over this alternative, nor would any minority groups be affected.

A diversion to the Wild Rice River would have a minor impact on community growth in West Fargo and Horace. Increased tax revenues would accrue to the communities from protection of currently flood-prone structures and the associated rises in property values. Some community expansion into floodplain areas may occur. The Wild Rice River diversion may, however, increase the viability of Horace by providing the community the stability necessary to attract future development.

A diversion to the Wild Rice River would create a minor temporary increase in employment for the construction trades. The diversion would also help protect existing jobs in businesses now subject to flooding in Horace and West Fargo.

To avoid an inequitable distribution of costs and benefits, a diversion to the Wild Rice River would be operated so as not to increase peak flood levels along the Red River of the North.

M-42 - This alternative would consist of a flood diversion channel to reduce flood stages along the Sheyenne River from Horace to Harwood by diverting flood flows from the Sheyenne River to the Red River of the North via the Wild Rice River. The diversion channel would start in Section 19 of Stanley Township about 1 mile southwest of Horace and proceed east for about 5 miles to join the Wild Rice River in Section 23 of Stanley Township near Wild Rice, North Dakota. The location of the channel is shown in figure L-1 (page L-36).

The diversion channel would be about 5.3 miles long, with a bottom width ranging from 15 to 40 feet and average depths ranging from approximately 10 to 13 feet for the different designs. The earth removed during construction would be placed on the overbanks adjacent to the channel.

The first cost of this alternative would range from $4 to $8 million for the sizes considered. The average annual costs for the three designs are $370,000, $440,000, and $510,000, respectively. No flood control benefits would be gained in areas upstream of this alternative. However, about $2 million in average annual flood control benefits could be credited, taking into account the fact that the diversion would be only partially effective during any given flood. These benefits are for estimating purposes only, and this alternative must be considered only a partial component of a plan.

The M-42 diversion would leave the Sheyenne River at the very downstream end of the segment qualified for potential inclusion in the Wild and Scenic River System; therefore, this diversion alignment does not have the potential

for as significant an impact on the scenic qualities of the river as other upstream alternatives. However, the riprapping and shaping of the diversion channel and the Sheyenne River diversion entry point would constitute an obvious intrusion by man and, therefore, would be considered a negative impact.

The alignment of the M-42 diversion would require the relocation of four farmsteads. However, 1,970 farmsteads and residences, 161 businesses, and 45 public facilities downstream would benefit.

Construction would require bridges or overpasses on I-29 and paved county roads. This construction would probably require traffic detouring for the county roads and temporary single-lane funneling of traffic on I-29.

No public facilities would be affected by the Wild Rice River diversion. The delivery of public services would be temporarily hindered in the Horace area by the structural modifications required to I-29 and the county roads.

Approximately 130 acres of cropland and 15 acres of other types of land would be required for construction of the 1,000-cfs design. The 2,000- and 3,000-cfs designs would require 160 and 210 acres of cropland, respectively, as well as 20 acres of other types of land. All of the lands required for construction include fish and wildlife mitigation lands.

Although flood damages at West Fargo, at Horace, and in the reach from Horace to West Fargo could be reduced, no ensured reduction in any specific flood can be attributed to this alternative because of the operational constraints imposed by levels on the Red River of the North. This alternative would have to be coupled with other alternatives that would reduce the levels of the first peak along the Sheyenne River.

M-54 - *This alternative would consist of a flood diversion channel from the Sheyenne River to the Wild Rice River similar to the diversion channel to the Wild Rice River at M-42.* The diversion channel would start in Section 24 of Normanna Township about 3 miles northeast of Kindred, and proceed east and northeast for about 3 miles to join the Wild Rice River in Section 10 of Pleasant Township about 5 miles southwest of Horace. The diversion channel could be designed to substantially reduce stages during the second peak of Sheyenne River flooding up to about the 1- to 2-percent chance floods. The location and features of the diversion channel are shown on figure L-1 (page L-36). Pertinent information on this alignment is contained in table L-1 (page L-34).

The diversion channel would be about 3 miles long, with a bottom width ranging from 15 to 40 feet and average depths ranging from approximately 11 to 14 feet, depending on the design size. The construction cost of this alternative would range from $2 to $6 million, depending on the size.

The annualized costs for the three possible designs are $220,000, $290,000, and $360,000. No flood control benefits would be gained in areas upstream of this alternative. However, from $1.5 to $2.0 million in flood control benefits could be gained. These benefits are for estimating purposes only, and this alternative must be considered only as a partial component of a plan.

The M-54 diversion would join the Sheyenne River within a segment that has potential for designation as a Wild and Scenic River. The riprapping and shaping of the diversion channel and the Sheyenne River diversion entry point would constitute an obvious intrusion by man and would, therefore, have a negative impact on this potential designation. The location of this intrusion would affect the significance of the impact since the length of relatively undisturbed river segments is important to Wild and Scenic River potential.

The alignment of the M-54 diversion to the Wild Rice River would not require the acquisition of farmstead buildings, residences, businesses, or public facilities. The diversion would benefit 2,000 farmsteads and residences, 161 businesses, and 45 public facilities located downstream.

The diversion would require bridges or overpasses on county roads, probably requiring traffic detours during construction. No public facilities would be affected by the diversion. The delivery of public services would be temporarily hindered in the Horace area by the structural modifications to county roads.

Approximately 80 acres of cropland and 5 acres of other types of lands would be required for construction of the 1,000-cfs design. The 2,000- and 3,000-cfs designs would require 90 acres and 100 acres, respectively, of cropland as well as 5 acres of other types of lands. All of the lands required for construction include fish and wildlife mitigation lands.

Although flood damages downstream of the inlet to the diversion could be reduced, no ensured reduction for any specific flood can be attributed to this alternative because of the operational constraints imposed by Red River of the North water levels. This alternative would have to be coupled with another alternative that would reduce the levels of the first peak along the Sheyenne River.

M-65 - This alternative would consist of a flood diversion channel from the Sheyenne River to the Wild Rice River similar to the diversion channel to the Wild Rice River at M-42. The diversion would start in Section 33 of Normanna Township about 1 mile southeast of Kindred and proceed east along Highway 46 for about 6 miles to join the Wild Rice River in Section 28 of Pleasant Township.

The diversion channel would be designed to substantially reduce flood stages during the second peak on the Sheyenne River for up to about the 1- to 2-percent chance flood. The location and features of the diversion channel are shown on figure L-1 (page L-36). Pertinent information on this alignment is contained in table L-1 (page L-34).

The diversion channel would be about 6 miles long, with a bottom width ranging from 15 to 40 feet and average depths ranging from approximately 12 to 14 feet depending on the design size.

The construction cost of this alternative would range from $5 to $9 million, depending on the size. The annualized costs for the three designs would be $440,000, $510,000, and $580,000. No flood control benefits would be gained in areas upstream of this alternative. However, from $1 to $1.8 million in flood control benefits could be gained. These benefits are for estimating purposes only, and this alternative must be considered only a partial component of a plan.

The M-65 diversion would join the Sheyenne River within a segment that has potential for designation as a Wild and Scenic River. The riprapping and shaping of the diversion channel and the Sheyenne River diversion entry point would constitute an obvious intrusion by man and, therefore, would have a negative impact on this potential designation. The location of this intrusion would be important to the impact since the length of a relatively undisturbed river segment is important to Wild and Scenic River potential.

The alignment of the M-65 diversion channel to the Wild Rice River would require the acquisition of one farmstead. However, the diversion would benefit 2,140 farmsteads and residences, 161 businesses, and 45 public facilities downstream of the alternative.

Construction of this diversion would require bridges or overpasses on county roads, probably requiring temporary traffic detours.

Approximately 170 acres of cropland and 20 acres of other types of land would be required for construction of the 1,000-cfs design. The 2,000- and 3,000-cfs designs would require 190 acres and 240 acres, respectively, of cropland as well as 20 acres of other types of land. All lands required for construction include fish and wildlife mitigation lands.

This alternative could reduce flood damages from Kindred through West Fargo. However, no ensured reduction for any specific flood can be attributed to this alternative alone because of the operational constraints imposed by Red River of the North water levels. This alternative would have to be coupled with another alternative that would reduce the levels of the first peak in the West Fargo area.

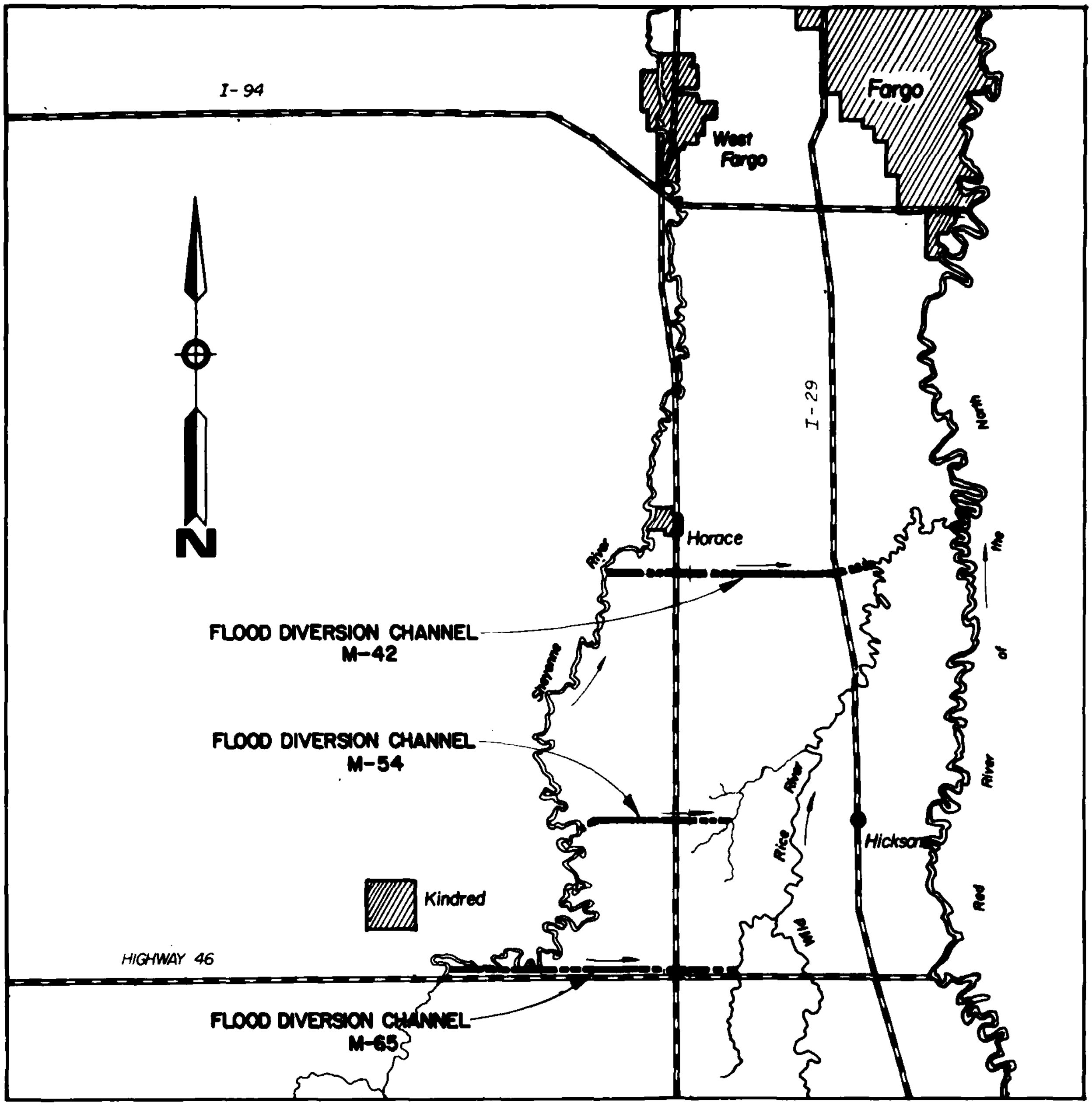
Table L-1 - Information on diversions to the Wild Rice River

Item	Site M-42			Site M-54			Site M-65		
	1,000 cfs	2,000 cfs	3,000 cfs	1,000 cfs	2,000 cfs	3,000 cfs	1,000 cfs	2,000 cfs	3,000 cfs
Channel design									
Bottom width (feet)	15	25	40	15	25	40	15	25	40
Top width (feet)	80	100	120	80	100	125	85	110	125
Length (miles)	5.3	5.3	5.3	3.0	3.0	3.0	5.9	5.9	5.9
Depth (feet)(with freeboard)	10	12	13	11	13	14.0	12	13	14
Economics									
First cost ($1,000,000)(1)	4 to 6	5 to 7	6 to 8	2 to 4	3 to 5	4 to 6	5 to 7	6 to 8	7 to 9
Average annual cost ($1,000)	370	440	510	290	290	360	440	510	580
Average annual flood control benefits ($1,000)	1,940	2,170	2,270	1,470	1,890	1,980	1,020	1,630	1,790
Benefit-cost ratio	5.2	4.9	4.5	6.7	6.5	5.5	2.3	3.2	3.1
Net benefits ($1,000)	1,570	1,730	1,760	1,250	1,600	1,620	580	1,120	1,210
Social effects									
Properties acquired									
Farmsteads and residences	4	4	4	0	0	0	1	1	1
Recreational dwellings	0	0	0	0	0	0	0	0	0
Public facilities	0	0	0	0	0	0	0	0	0
Properties benefited									
Farmsteads and residences	1,970	1,970	1,970	2,000	2,000	2,000	2,140	2,140	2,140
Businesses	161	161	161	161	161	161	161	161	161
Public facilities	45	45	45	45	45	45	45	45	45
Persons relocated	12	12	12	0	0	0	3	3	3
Persons benefited (2)	9,400	9,400	9,400	9,500	9,500	9,500	9,900	9,900	9,900
Lands required (acres)									
Cropland	130	160	210	80	90	100	170	190	240
Other	15	20	2	5	5	5	20	20	20
Lands benefited									
Cropland	6,000	6,000	6,000	18,600	18,600	18,600	23,000	23,000	23,000
Urban	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800
Other	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800
Transportation - roads severed	0	0	0	0	0	0	0	0	0
Flood damage reduction effectiveness									
Reduces 1-percent chance flood level:									
Valley City	0	0	0	0	0	0	0	0	0
West Fargo(3)	?	?	?	?	?	?	?	?	?
Frequency of design flood (percent)	15(4)	10(4)	3(4)	15(4)	10(4)	3(4)	15(4)	10(4)	3(4)

(1) October 1978 price levels.
(2) Benefited by reduced flood damages.
(3) No ensured reduction for any specific flood; see text.
(4) Variable depending on when diversion can be operated.

Table L-2 - Summary of impacts associated with diversions to the Wild Rice River

Impact category	Site M-42 (1,000 cfs / 2,000 cfs / 3,000 cfs)	Site M-54 (1,000 cfs / 2,000 cfs / 3,000 cfs)	Site M-65 (1,000 cfs / 2,000 cfs / 3,000 cfs)
Habitat			
Woodland	About 2 acres. Low value, although further removed from urban areas. Provides some use for deer and other wildlife.	About 5 acres of woodlands affected, including 3 acres of woodlots. The woodlands provide moderate value to birds and small wildlife species. Some use by deer.	About 5 to 10 acres of woodland and brush would be affected by the project. Low to medium wildlife value because of scarcity of habitat. Use by birds and small mammals and maybe occasional deer.
Cropland	50 acres. 60 acres. 70 acres. Low value because cropland is abundant in area.	About 30 acres. About 35 acres. About 40 acres. Low wildlife value. Not much other habitat around for interspersion. Abundant cropland available in area.	About 50 acres. About 60 acres. About 70 acres. Low wildlife value. Abundant cropland in area and not much interspersion available.
Grassland	None affected.	About 10 to 15 acres of grassland affected where diversion would utilize existing topographic drainage. Low value for birds and small mammals because of lack of interspersion.	About 10 to 15 acres affected. Some use by birds and small mammals.
Wetland	About 2 acres. A county ditch provides some seasonal wetland habitat.	Some seasonal wetlands may exist in the drainage channels.	There may be some seasonal wetlands in the natural drainages.
Fish	No impact.	No effect. Most of the diversion goes through agricultural lands.	No effect. Most of diversion goes through agricultural land.
Miscellaneous			
Rare plants and animals	No effect.	Waterwort (a rare plant in North Dakota) could be affected. It is an aquatic plant found along shorelines in the vicinity of the Wild Rice River.	None known.
Water quality	Temporary increase in turbidity during construction.	Temporary increase in turbidity during construction. Minor impacts on fish and wildlife.	Temporary increase in turbidity during construction. Minor impacts on fish and wildlife.
Aesthetics	Minimal adverse effect. Construction disturbances would be negative.	Construction and postconstruction disturbances will be negative.	Construction and postconstruction disturbances will be adverse.
Planning constraints			
E.O. 11988 (floodplain)	This alternative is located in the floodplain and could change land use and nature of future developments.	Project would be constructed in the floodplain and may change nature of future developments.	Project would be constructed in the floodplain and may change nature of future developments.
E.O. 11990 (wetlands)	Minor. Some wetland type habitat is in existing ditch bottom.	Some wetlands in drainage channels would be affected.	Some wetlands in the drainage channels would be affected.
Preserve riverine environment	Very minimal effect on riverine environment.	Very minimal effect on riverine environment.	Very minimal effect on riverine environment.
Federal threatened and endangered species	None known.	None known.	None known.
Federal and State wild and scenic rivers	The diversion channel is an intrusion by man and therefore a negative impact. Located at downstream end of proposed river segment.	The project is an intrusion by man and is therefore a negative impact on wild and scenic river designation.	The project is an intrusion by man and is therefore a negative impact on wild and scenic river designation.
Areas of critical national importance			
Game management areas, refuges, grasslands, etc.	No effect.	No effect.	No effect.
Cultural resources	Unknown impacts on cultural resources.	Unknown impacts on cultural resources.	This alternative would not affect any known cultural resources; however, undetected cultural resources could be affected.



US ARMY CORPS OF ENGINEERS
ST. PAUL, MINNESOTA
PHASE I GENERAL DESIGN MEMORANDUM
SHEYENNE RIVER, NORTH DAKOTA

LOCATION OF FLOOD DIVERSIONS
TO THE WILD RICE RIVER

JANUARY 1982

Figure L-1

Channelization - Sheyenne River

This alternative was considered in two parts:

a. Enlargement and straightening of the Sheyenne River channel from near Kindred (about river mile 68) to West Fargo (about river mile 30) where it could join the diversion and levee system or other form of local protection at West Fargo/Riverside.

b. Enlargement and straightening of the Sheyenne River channel from West Fargo (about river mile 24) to the mouth.

The enlarged and straightened channel would involve approximately 38 miles of river channel from Kindred to West Fargo and 24 miles of river channel from West Fargo to the mouth. The bottom width would be 50 feet, and the average depth would be approximately 10 feet and would be able to convey approximately 3,100 cfs for each reach. Excavation would be limited, where possible, to one side of the existing channel to minimize environmental and social impacts.

The construction costs would range from $13 to $26 million for the Kindred to West Fargo reach and from $10 to $21 million for the West Fargo to mouth reach. The average annual costs would be $1.5 million to $1.2 million, respectively. The estimated average annual benefits would range from $0.74 to $0.54 million, resulting in a benefit-cost ratio of 0.5 and 0.4 for the two reaches, respectively.

In the area downstream of Kindred, most of the remaining vegetation is along the river. Channelization would affect and possibly destroy vegetation within 25 feet of either riverbank. Therefore, from Kindred to West Fargo, a minimum of 500 acres of vegetation, primarily woodland, would be affected. From West Fargo to the mouth, a minimum of 390 acres of vegetation would be affected. This represents a major portion of the remaining wildlife habitat in a reach that is agriculturally oriented.

The downstream reacn between Kindred and the mouth supports a wintering deer population and provides habitat for other wildlife. Removal of a large portion of the remaining woodlands along the river would have a significant impact on wildlife populations. The vegetation-water interface is one of the most valuable wildlife habitats for birds and semiaquatic organisms. For example, a study in northern Arizona showed that (1) vegetation manipulation in native riparian communities was extremely detrimental to breeding bird populations, the extent of the impact being significantly correlated with the degree to which phreatophytes were removed and (2) for a given number of acres of habitat, the riparian type supports higher population densities than any other forest habitat type. When a riparian habitat is removed or severely manipulated, not only are the riparian species of the area adversely influenced, but wildlife productivity in the adjacent habitat is depressed. This zone of influence may extend several hundred meters beyond the edge of the streamside vegetation (Carothers, S.W., R.R. Johnson, and S. W. Aitchision, 1974. "Population Structure and Social Organization of Southwestern Riparian Birds." American Zoology, 14: 97-108. Cited by Johnson, R.R., and D.A. Jones, ed., 1977, "Importance, Preservation and Management of Riparian Habitat: A Symposium." USDA Forest Service, General Technical Report, RM-43. 217 p.).

The existing river fishery, although probably of low value, would be adversely affected by this alternative. The fish habitat, debris, logs, and so on, would be removed from the river. Trees along the bank, which provide shade and a source of future fish habitat, would be removed. The game fish populations would decline as a result of channelization. Rough fish, such as redhorse and carp, would increase, and the recreational value of the river would decline.

The Kindred to West Fargo reach of this alternative would include a portion of the Sheyenne River which has potential for selection as a wild and scenic river. About 25 miles of the Sheyenne River from Kindred to Horace is so classified. The widening, deepening, and straightening of this

river segment would obviously preclude future consideration for wild and scenic river designation. However, this measure would not affect the remaining 182 miles of the Sheyenne River which meets designation standards.

The channelization would not involve the acquisition of any farmsteads and residences, businesses, or public facilities. The Kindred to West Fargo reach of channelization would benefit 400 farmsteads and residences, 11 businesses, and 5 public facilities. The West Fargo to mouth reach of channelization would benefit 560 farmsteads and residences, 6 businesses, and 2 public facilities. All of these properties would benefit from reduced flood damages.

Channelization would also have a significant impact on aesthetics. The enlarging and straightening of the river would destroy existing riparian vegetation and the natural character of the meandering river. The riverbanks would be unsightly and turbidity would be high until the banks were vegetated.

The noise associated with construction of the new channel would have minimal effects in the rural areas because few people are in these areas. However, in the urban areas, the noise would have a major impact because the large number of people near the construction. Following construction, noise levels associated with the operations and maintenance of the channel would be negligible.

Approximately 2,150 acres of land would be required for construction of the Kindred to West Fargo reach of channelization. The West Fargo to the mouth reach would require 1,700 acres of land. These lands include the fish and wildlife mitigation lands and are composed mainly of woodlands.

No reductions in flood levels at West Fargo are estimated for the channelization because channelization should be coupled with the diversion and levee system around West Fargo/Riverside.

Kindred Dam (Dry Reservoir at Mile 76)

This alternative would consist of an earth fill dam near Sheyenne River mile 76 approximately 5 miles southwest of Kindred and near the center of section 14 of Barrie Township. A plan view and typical embankment section are illustrated in figure L-2.

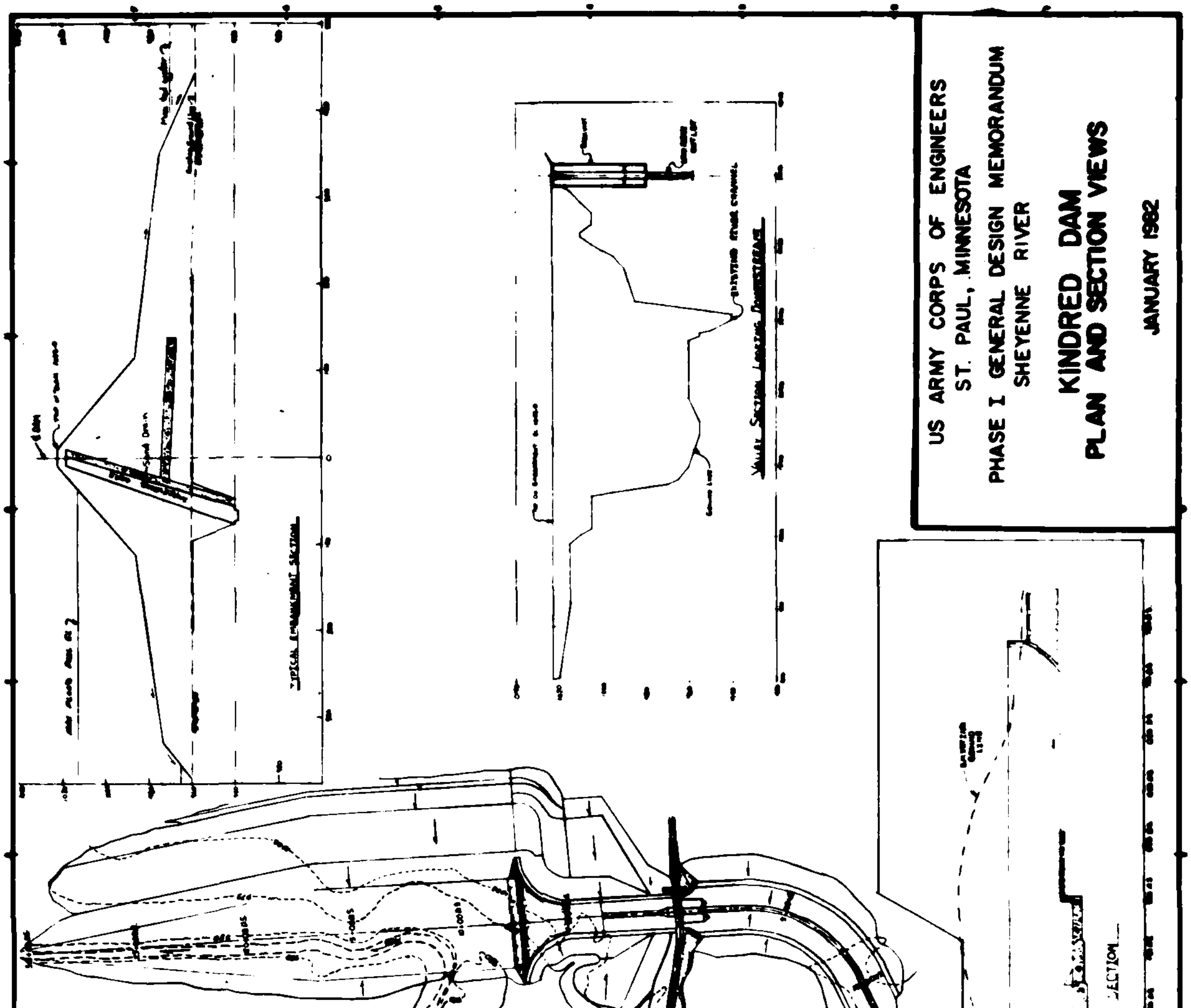

US ARMY CORPS OF ENGINEERS
ST. PAUL, MINNESOTA
PHASE I GENERAL DESIGN MEMORANDUM
SHEYENNE RIVER
KINDRED DAM
PLAN AND SECTION VIEWS
JANUARY 1982
TYPICAL EMBANKMENT SECTION
PLAN VIEW
SPILLWAY SECTION
SCALE

FIGURE L-2

A dry reservoir would have no permanent pool, and the dam would be operated only for flood control. Three different design flood pool elevations were analyzed: 1000, 1010, and 1015 feet msl. The flood control storages for the three designs would be 180,000, 300,000, and 360,000 acre-feet, respectively. Because an additional 20,000 acre-feet of storage is required for sediment storage, total storage requirements of 200,000, 320,000, and 380,000 acre-feet, respectively, would be needed. The areas flooded by the three design flood pools would be 9,600, 12,400, and 14,000 acres, respectively.

The 1000-foot elevation flood pool design would require a top of dam elevation of 1010 feet, resulting in a 79-foot high structure. The 1010 and 1015 flood pool designs would require tops of dam at 1020 feet and 1025 feet, respectively. The resulting heights of the dams would be 89 feet for the 1010 flood pool and 94 feet for the 1015 flood pool.

Each design would have a gated spillway with gated conduit low-flow outlet works. To evaluate the ability of the structures to control the 1-percent chance flood to a minimum level of release, the resulting uniform release rate for the 1000-foot elevation flood pool would be 3,000 cfs. The 1010 and 1015 flood pool designs would have release rates of 1,600 and 1,000 cfs, respectively. Since nondamaging flow levels are about 2,000 to 2,500 cfs in the reach below Kindred, the 1000-foot dam would only be capable of controlling a lesser frequency flood at nondamaging levels.

The first costs of the designs would range from \$45 to \$70 million: the 1000-foot flood pool would cost \$45 to \$55 million, the 1010-foot flood pool would cost \$55 to \$65 million, and the 1015-foot flood pool would cost \$60 to \$70 million. The average annual costs for the designs would be \$4.4, \$5.2, and \$5.6 million, respectively.

The total flood control benefits are based on operation of the reservoir to control the 1-percent chance flood at Kindred at the minimum uniform release rate depending on the amount of flood control storage available. These benefits would come to $13.0 million for the 1000-foot elevation flood pool, yielding a benefit-cost ratio of 2.9. The 1010- and 1015-foot flood pool benefits would be $19.5 and $19.8 million, respectively, yielding benefit-cost ratios of 3.7 and 3.5.

Revising the operating plan for the smaller dam to control releases at nondamaging levels would probably improve the benefit-cost ratio. Additional operating plans and combinations would need to be evaluated to optimize the plan levels.

More significant impacts of constructing a flood control dam near Kindred are discussed below. As more information becomes available, the discussion will be expanded. Specific data concerning the types and amounts of the various habitats affected and a summary of environmental impacts are contained in table L-4.

Table L-3 - Pertinent information on Kindred Dam
(dry reservoir at mile 76)

Item	Design flood pool elevation (feet msl)		
	1000	1010	1015
Data			
Storage capacity (acre-feet)			
Flood control	180,000	300,000	360,000
Sediment	20,000	20,000	20,000
Total	200,000	320,000	380,000
Area flooded at design flood pool (acres)	9,600	12,400	14,000
Dam			
Type	---------Earth fill-----------		
Elevation, top of dam (feet msl)	1010	1020	1025
Height (feet)	79	89	94
Spillway (type)	Gated	Gated	Gated
Low-flow outlet works (type)	Gated conduit	Gated conduit	Gated conduit
Uniform release rate (cfs)	3,000	1,600	1,000
Economics			
Costs			
First cost ($ million)	45 to 55	55 to 65	60 to 70
Average annual cost ($1,000)	4,400	5,200	5,600
Flood control benefits ($1,000)[1]	13,000	19,500	19,800
Benefit-cost ratio	2.9	3.7	3.5
Net benefits ($1,000)	8,600	14,300	14,200
Social effects			
Properties acquired			
Farmsteads and residences	32	52	57
Recreational dwellings	4-H camp	4-H camp	4-H camp
Public facilities	1 church	2 churches	2 churches
Other	1 cemetery	2 cemeteries	2 cemeteries
Properties benefited[2]			
Farmsteads and residences[2]	2,600	2,600	2,600
Businesses[2]	167	167	167
Public facilities[2]	47	47	47
Persons relocated[3]	100	160	170
Persons benefited[4]	11,590	11,590	11,590

Table L-3 - Pertinent information on Kindred Dam (dry reservoir at mile 76)(cont)

Item	Design flood pool elevation (feet msl) 1000	1010	1015
Lands required (acres) (5)	12,000	16,000	18,000
Total	(25,000)	(31,000)	(36,000)
Cropland	4,100	5,400	5,900
Other	7,900	10,600	12,100
Lands benefited (2)			
Cropland (2)	50,000	50,000	50,000
Urban (2)	1,000	1,000	1,000
Transportation - roads severed	11	14	14
Flood damage reduction effectiveness:			
Reduces total flood damages (percent):			
Valley City	0	0	0
West Fargo	55	85	85
Total Sheyenne River	45	70	70
Reduces 1-percent chance flood level			
Valley City	0	0	0
West Fargo	(6)	(6)	(6)

(1) Based on operation to control 1-percent chance flood at Kindred to the minimum uniform release rate based on amount of flood control storage available.

(2) Properties benefited along the Sheyenne River; does not include benefits along Red River of the North. At Grand Forks, North Dakota, about 2,400 residences, 200 businesses, and 40 public buildings would benefit. Additional areas along the Red River would also benefit.

(3) Based on approximately three persons per residence; does not include relocations from fish and wildlife mitigation lands.

(4) Benefited by reduced flood damages along the Sheyenne River; does not include Red River of the North.

(5) Only the total figure in parentheses includes fish and wildlife mitigation lands; the breakdown of types of lands does not include mitigation lands.

(6) Flood levels would be significantly reduced in the West Fargo area; however, the amount of reduction for a specific flood would depend in part on the backwater effects from the Maple River and the Red River of the North.

Table L-4 - Summary of impacts associated with Kindred Dam alternatives

Factor affected	Impact: Dry dam elevation 1000	Impact: Dry dam elevation 1010	Impact: Wet dam - elevation 1015 (permanent pool 975)
Habitat			
Woodland	Design pool would affect 4,340 acres of woodland (1, 10, and 19 percent of the woodland in the State, Richland and Ransom Counties, and Ransom County, respectively). Infrequent floods would affect an additional 635 acres.	Design pool would affect 5,605 acres of woodland; infrequent floods would affect another 725 acres.	Design pool would affect 6,330 acres of woodland. 1,470 acres would be permanently lost in the conservation pool. A wet dam creates more adverse impacts than a dry dam. Conservation pool would be 100 percent lost. Dry dams would be slightly less than 100 percent, depending on recovery and flooding regime.
	Woodlands in the lower basin are extremely valuable as food/cover for wildlife and are used heavily by birds, deer, and other mammals. The area provides habitat for many rare species of birds in North Dakota. An experimental planting of Scotch pine obtained from Russia would be destroyed; this planting is not replaceable. All of these variations would have very significant impacts on the woodland and wildlife in this portion of North Dakota. Woodland is extremely rare in North Dakota and continued wildlife production depends on its preservation. The woodland is particularly important to deer.		
Cropland	Design pool would affect 3,610 acres; infrequent floods would affect another 525 acres.	Design pool would affect 4,665 acres; infrequent floods would affect another 600 acres.	Design pool would affect 5,265 acres; 1,220 acres would be in the permanent pool.
	Wildlife use of cropland is light. Edges of cropland are most heavily used; it also has interspersion value. Cropland is abundant outside of the valley proper. Fish and wildlife impacts because of cropland loss would not be significant.		
Grassland	Design pool would affect 1,375 acres; infrequent floods would affect another 200 acres.	Design pool would affect 1,780 acres; infrequent floods would affect another 230 acres.	Design pool would affect 2,015 acres; 470 acres would be 100 percent lost in the permanent pool.
	Most of the grassland sites visited were grazed or hayed and therefore were of moderate wildlife value. Interspersion with other habitat types increases value of grassland. Some areas are used for grazing in the Sheyenne National Grasslands. Some economic impacts would result from reduced grazing capacity. With the project, certain areas would be entirely unsuitable for grazing. All three alternatives would have significant adverse effects on grasslands. Prairie chicken populations (very rare) are concentrated in the grassland areas.		
Wetland	Design pool would affect 275 acres; infrequent floods would affect another 40 acres.	Design pool would affect 350 acres, infrequent floods would affect another 45 acres.	Design pool would affect 390 acres [illegible] acres would be 100 percent lost in the permanent pool.
	The wetlands in this area provide good to excellent habitat for furbearers, waterfowl, and nongame aquatic species. Most areas are oxbows or marsh areas on uplands. Fluctuating water levels would destroy much of the vegetation, create bare shoreline, mud flats, and weedy growth less desirable for wildlife.		
Fish	About 40 river miles affected.	About [illegible] river miles affected.	[illegible] river miles affected. About [illegible] and [illegible] miles of river [illegible] habitat [illegible] dam impact [illegible] the first few years of impoundment would have good fishery [illegible]
	The dry dam may have a benefit downstream because of increased flows, higher [illegible] levels, etc. The duration of storage would be sufficient to kill some of the vegetation, thereby reducing or eliminating some fishery habitat. Decomposition [illegible] stream of the dam may create a high oxygen demand and result in some fish [illegible]. Invertebrate populations would be killed in the pool area because of different water characteristics.		
Miscellaneous			
Rare plants and animals	There are 19 species of plants found in the impoundment area that are not found elsewhere [illegible] plants have their greatest abundance in this area. Two species of birds that are [illegible] State nest in this ecosystem, and several other rare birds nest in the area.		
Water quality	The dry dam would create a large area of dead vegetation, bare shoreline, and [illegible] weedy growth which would cause erosion problems around the reservoir. The outflow from the dry dam would probably be more turbid and contain more nutrients than [illegible] flows from a wet dam. There may be less productivity in the dry dam, but algal blooms would be possible.		[illegible] and sediment [illegible] raising the water table would affect vegetation [illegible] agricultural lands. The permanent pool would act as a sediment and nutrient trap. [illegible] water levels, dead vegetation, and denuded shoreline would result [illegible]. Algal blooms would probably occur.
Aesthetics	The distinctive riparian landscape could be inundated up to 200 days. Loss of vegetation, potential increases in erosion of valley walls, invasion of less desirable weedy species, and wildlife population decline are significant negative aesthetic effects. Unvegetated shoreline would be aesthetically undesirable. Reduction of flood damages is a positive effect.		The permanent pool would inundate a distinctive landscape. [illegible] of the forested area in the basin lies in the project area. The destruction of this vegetation and loss of wildlife would have a significant adverse effects. Flood pool impacts would be similar to those of a dry dam.
Planning constraints			
E.O. 11988 (Floodplain)	Project would modify some floodplain lands, reduce the size of the downstream floodplain, possibly change the nature of future development downstream, and may change land-use patterns.		
E.O. 11990 (Wetlands)	The dams would affect some excellent wetland habitat. The wet dam would permanently destroy some wetlands. The upstream end of the permanent pool may create some wetland. Modified sedimentation patterns and storage patterns would adversely affect some wetlands.		
Preserve riverine environment	The dry dams because of the frequency and duration of flooding, would destroy or modify a large portion of the river corridor. Undesirable weedy vegetation of lower wildlife value would invade the area.		The permanent pool would destroy 3,250 acres of riverine environment; the flood pool destroys or severely modifies another 11,750 acres. Severe, significant impacts result.
Federal threatened and endangered species	There are no known impacts on Federal threatened or endangered species. The bald eagle and peregrine falcon (endangered) may migrate through the area but do not nest there. The Dakota skipper butterfly (proposed) is from the area and would be adversely affected.		
Federal and State Wild and Scenic Rivers	All of the alternatives are located in the area that has been selected for study for possible inclusion into the Federal system. All alternatives would preclude future inclusion into the system. The State also considered this portion of the river for possible State status. Impacts would be similar. About 30 miles of river would be affected by the conservation pool; up to 55 miles would be affected by the flood pool.		
Areas of critical national importance			
Game management areas, refuges, national grasslands, etc.	All alternatives would affect the Mirror Pools Game Management Area which has been identified by the Citizens Committee as a priority area for preservation. Parts of the Sheyenne National Grasslands would be inundated by the pools. Groundwater level increases (resulting from a permanent pool only) would change the vegetation patterns in the Sandhills area which would change wildlife use, domestic grazing values, etc. Impacts increase as pool levels increase and as permanent storage occurs, although all alternatives are significantly adverse.		
Cultural resources	Four known historic sites and 11 known prehistoric sites exist within the design pool (elevation 1017). Many more undetected sites may exist within the dam area. The dry dam alternative would cause erosion problems which would have an adverse effect on cultural resources. An alternating wet-dry cycle may accelerate decomposition of certain types of cultural materials.		Two known historic sites would be permanently inundated by the permanent pool as might other undetected sites. The effects of erosion may affect other sites located along the perimeter of the permanent pool. Inundation may accelerate decomposition of certain types of cultural materials.

Kindred Dam would affect a large area of diverse vegetation and wildlife which is currently relatively free from human disturbance. The many species of rare plants found in the area between Kindred and Anselm provide habitat for several rare species of wildlife, including the pileated woodpecker and barred owl.

The woodland in the basin is very important for wildlife species, particularly white-tailed deer which use the area extensively for winter cover. The number of deer seen during the winter aerial surveys of the lower basin was 40 percent higher in 1977 than the previous year. Other upland and lowland species of wildlife also use these wooded areas extensively.

At elevation 1000, the design pool of the smallest dry dam alternative would affect 1, 10, and 19 percent of the woodland in the State, Richland-Ransom Counties, and Ransom County, respectively. This loss would be significant in a State that is only 1-percent forested. The aesthetic and wildlife value of these woodlands is very high and to some degree irreplaceable. According to stage-duration-frequency curves, the area below about elevation 975 feet would be inundated frequently enough and for sufficient durations to modify much of the existing vegetation. Although an occasional scattered tree might escape the flooding or be regrown between floods, dominant species would probably be weeds and small water-tolerant brush.

If a dry dam is justified, a small conservation pool could be added to provide storage for recreation and conservation; however, it would completely destroy 1,470 acres of woodland which accounts for 4 percent of the woodland in the basin and 28 percent of the woodland in Ransom County. This amount does not include the significant losses that would occur in the flood pool. It would take a number of years after a large flood for the area to recover, depending on the habitat type and subsequent flooding.

An experimental shelterbelt planting of Scotch pine in the pool area would be periodically flooded. The seed was obtained from the Russian Government and is deemed to be irreplaceable. The test planting is less than halfway to the age where performance data can be evaluated. On the basis of frequency curves, the trees are in an area that would have an inundation frequency of about 5 percent. The duration and elevation of flooding could be sufficient to kill the trees.

The wildlife value of affected cropland is low. The edges of the cropland are most heavily used by rodents and birds and provide value through their interspersion with other habitat types. Cropland is abundant outside the valley proper. This fact, coupled with the relatively low wildlife value of the cropland, results in rather insignificant fish and wildlife impacts through the loss of cropland. The alternatives would, however, be located in an area that has been classified as prime farmland by the Soil Conservation Service.

Grassland would be adversely affected by all three alternatives. Most of the grassland in the project area is grazed or hayed and, therefore, of moderate wildlife value. The grassland does, however, provide habitat for many species that require open or edge habitat. The interspersion value of the grassland is important. In addition, some areas in the Sheyenne National Grasslands are leased to local interests for grazing. As a result, reduced or eliminated grazing capacity would have some economic impact on these individuals.

The regrowth of weedy vegetation or other less desirable forage species would make these areas unsuitable for grazing by domestic livestock. As a result of inundation, the regrowth would also be undesirable for many wildlife species. (See Appendix D for a discussion of the effects of inundation on vegetation.)

The wetlands in this area usually consist of abandoned oxbows. These oxbows provide good to excellent habitat for furbearers, waterfowl, and nongame semiaquatic species. The fluctuating water levels in the frequently inundated areas would kill much of the vegetation, create bare shorelines, and result in mud flats and weedy growth less desirable for wildlife.

Both adverse and beneficial fish impacts would be associated with a dry dam at Kindred. The dry dams would affect 45 to 55 miles of river. These alternatives have the potential to benefit the downstream fishery through increased flows, higher oxygen levels, etc. In the reservoir itself, fish habitat could be reduced, higher oxygen demands could result in fish kills, and invertebrate populations would be affected. The limited fish benefits downstream would not appear to offset the impacts incurred in the pool area.

North Dakota has few endemic species. The flora of the area is a derived one in that the species that occur here have evolved elsewhere and have migrated into the area. Many species have their limits of distribution within the boundaries of North Dakota. As a result, there are many species of rare occurrence in North Dakota.

Nineteen species of plants found in the impoundment area are not found elsewhere in North Dakota. Some of these are bloodroot (Sanguianaria canadensis), bedstraw (Galium sp.), burning bush (Euonymus atropurpureus), false Solomon's seal (Smilacina racemaea), and black snakeroot (Sanicula gregaria). This area of the State is unique in that it is capable of sustaining these plant species. Just as important as the plants themselves are the microclimate and phytosociological characteristics of the area that make it possible for these species to exist there. The area and the vegetation have aesthetic, wildlife, genetic, recreational, social, and economic importance.

In addition to the species listed above, 31 other plants have their greatest abundance in this area. Some of these include sensitive fern (*Onoclea sensiblis*), jack-in-the-pulpit (*Arisrema tryphyllum*), wild ginger (*Asarum canadense*), and basswood (*Tilia americana*). These species are most abundant in the lower basin or attain their largest size there. For example, in the lower basin, basswood attains a size and distribution not matched elsewhere in North Dakota.

With this rare plant community of the lower Sheyenne River basin and the sandhills is associated a unique population of birds and amphibians that are rare in North Dakota. The barred owl and cerulean warbler nest only in this area of North Dakota. In addition, several other birds classified as rare in North Dakota nest in this ecosystem: scarlet tanager, yellow-billed cuckoo, yellow-bellied sapsucker, yellow-throated vireo, pileated woodpecker, green heron, and American woodcock. Also, the wood frog and red-sided garter snake have been noted only in this area of the State. In addition, about 95 percent of the State's population of prairie chickens is found in the sandhills area. The exact impacts on vegetation/wildlife of raised water levels in conjunction with a permanent conservation pool have not been fully evaluated. However, additional evaluations by th U.S. Geological Survey[1] indicate that potential raises of groundwater in adjacent areas is significantly less than predicted in its earlier (1974) reports.

The types of water quality impacts associated with wet and dry dams are similar; they vary mainly in magnitude. Fluctuating water levels, denuded shorelines, dead vegetation, and sparse weedy vegetation would encourage erosion, giving the reservoir what is commonly referred to as a "bathtub ring" appearance. The dry dams, because of the larger fluctuations

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(1) Supplement to Predictive Modeling of Effects of the Planned Kindred Lake on Ground-Water Levels and Discharge, Southeastern North Dakota, U.S. Geological Survey, June 1981.

would probably create more erosion. The permanent pool in the wet dam would act as a sediment and nutrient trap. Thus, the outflow from the dry dam would probably be more turbid and contain more nutrients than the wet dam outflow. Algal blooms would probably occur with the wet dam and might be possible with the dry dam. The permanent pool might produce higher groundwater levels in surrounding land which could change the vegetative composition and forage values for domestic and wild grazing species. An increase in groundwater levels also could render some areas unsuitable for growing crops.

The lower Sheyenne River basin has very high aesthetic qualities because of its distinctive riparian landscape. The alternatives would destroy some of these qualities through permanent inundation and/or temporary inundation lasting up to 200 days. The loss of vegetation, increased erosion of valley walls, loss of wildlife, and invasion of less desirable weedy species would have significant negative aesthetic impacts.

All Kindred Dam alternatives would be incompatible with the objective of preserving the riverine environment. Permanent and temporary inundation would destroy much of the vegetation and result in the invasion of less desirable weedy species. The impacts on vegetation, aesthetics, and wildlife would be significant.

These alternatives are not anticipated to have adverse effects on any Federal threatened or endangered species. The bald eagle, whooping crane, and peregrine falcon may be found in the area during migration but do not nest in the area. The Dakota skipper butterfly (proposed species) is found in the area in association with ungrazed prairie land and would be adversely affected by the Kindred Dam alternatives.

All of the alternatives would be located in the area that is being considered for inclusion in the Federal system of wild and scenic rivers. All alternatives would work against inclusion of the area in the system. The dry dam would have the least impact but is still considered negative.

The State of North Dakota has also considered this portion of the river for possible State wild and scenic river status. The State selection criteria are similar to the Federal; therefore, the impacts would be similar.

If a wet pool were implemented, the normal conservation pool level would probably range in elevation from 950 to 980 feet msl. The maintenance of a permanent pool would have direct adverse impacts on the potential of 15 to 30 river miles for designation as wild and scenic river (depending on which conservation pool design was implemented). The flood pools would periodically back up behind Kindred Dam, regardless of whether the proposed dam is dry or wet, and would affect 45 to 55 river miles. The wild and scenic river designation potential of this river segment would be significantly and adversely affected. The Kindred Dam alternatives would not affect the wild and scenic river potential of the river segment from Valley City to the upstream flood pool (river mile 121 or 131 depending on the selected design). Reservoir operation (manipulation of river flow) could have some minimal indirect adverse effects on downstream portions of the river from the dam (river mile 76) to Horace (river mile 43).

If a Kindred Dam alternative were built, the Mirror Pools GMA (Game Management Area) in Richland and Ransom Counties would be adversely affected. This GMA is 547 acres in size. Game management is aimed at white-tailed deer, but squirrels, pheasants, cottontail rabbits, and waterfowl are also abundant. An outstanding feature of this GMA is a series of spring-fed ponds. These ponds and their associated biota form a unique ecosystem not duplicated anywhere else in the basin. Originally, the North Dakota Game and Fish Department planned to develop these ponds for fish production. However, constraints on manpower and funding have inhibited development.

A Federal area that could be adversely affected by the alternatives is the Sheyenne National Grasslands. This area is administered by the National Forest Service to help promote grassland agriculture. Although wildlife management is not one of its primary objectives, the grassland provides quality habitat for a variety of wildlife species. Although a Kindred Dam alternative would adversely affect some of the more wooded areas of the grasslands, the potential effects of an increased groundwater level are also of concern. Studies completed by the U.S. Geological Survey and North Dakota State University make it possible to predict these impacts; however, the actual impacts have not been determined. A preliminary analysis indicates that these effects would be limited in both area affected and amount of change induced. A habitat analysis was completed on both the grassland and wooded portions of the National Grasslands. Compensation for the loss of wooded areas is contained in the mitigation figures. Compensation for the loss of grassland outside the project area would be determined when the aforementioned study is completed.

All three of the dam designs would involve the acquisition of properties. The 1000-foot elevation flood pool design would affect 32 farmsteads and residences, 1 4-H camp, 1 church, and 1 cemetery. The 1010-foot elevation flood pool design would affect 52 farmsteads and residences, 1 4-H camp, 2 churches, and 2 cemeteries. All three sizes would benefit 2,600 farmsteads and residences, 167 businesses, and 47 public facilities along the Sheyenne River. These benefits do not include other areas along the Red River of the North which would also benefit from an alternative of this magnitude. For example, at Grand Forks, North Dakota, about 2,400 residences, 200 businesses, and 40 public buildings would also benefit.

Estimating 3 persons per residence and using the number of residences acquired for each design, approximately 100 persons would have to be relocated for the 1,000-foot elevation flood pool design, 160 persons for

the 1010-foot elevation flood pool design, and 170 persons for the 1015-foot elevation flood pool design. However, this alternative would benefit about 11,590 persons along the Sheyenne River by reducing flood damages. People along the Red River of the North would also benefit.

Noise levels would be temporarily increased during reservoir and dam construction. However, because of the rural character of the area and the distances from people who might be affected, the increases would not significantly affect any individuals or groups.

Populations in West Fargo and Riverside and rural areas between Kindred and West Fargo might increase as a result of the Kindred Dam. By protecting these floodplain areas, the alternative may induce greater development in the area currently defined as floodplain. However, residential development of floodplain areas in the West Fargo area is increasing rapidly despite the absence of any urban flood protection. This development appears to be supported in part by the guarantee against large-scale loss provided by the Federal Flood Insurance Program and by lower development costs than in non-floodplain areas.

Kindred Dam would have a significant impact on aesthetics. The protection that this alternative would provide for West Fargo and Riverside would benefit aesthetics by preventing further deterioration of existing structures in the floodplain and the temporary visual blight caused by deposition of mud and debris during floods. However, this alternative would alter the character of a regionally significant scenic stretch of the Sheyenne River. It would also require the clearing of a large area of bottomland hardwood trees and some prime waterfowl habitat. It would inundate 4,400 acres of hardwoods and 600 acres of wetlands on a temporary basis.

Recreation in the grasslands would also be affected by a permanent pool. Public use of the grasslands would increase somewhat because of the increased visitation to the reservoir area. Recreational activities associated with the reservoir might increase public use and result in a loss of solitude. This alternative might also threaten some of the more vulnerable historic and archaeological sites in the area.

The major use of the grasslands by area residents has been livestock grazing. Not all people in the area have grazing permits on the grasslands, but those who do depend on this grazing to maintain their operations. The current contribution to the local economy of livestock grazing, nonresident recreation use, and water production on the Sheyenne National Grasslands is estimated to be less than 1 percent of the total income for Ransom and Richland Counties. Employment attributed directly to output from the Sheyenne National Grasslands is relatively minor when the area as a whole is considered, but the grasslands are very important to the operations of 102 ranches who do have permits and whose operations would be threatened without the use of the grassland. If the Kindred Dam alternative were to alter vegetative patterns enough to decrease grazing potential, the adverse consequences could be significant. This impact would be particularly serious because this group of farmers and ranchers would already be significantly affected by the required acquisition of lands.

The effects on the Sheyenne National Grasslands of an increase in groundwater levels caused by a dry dam at Kindred would probably be minor because of the temporary nature of the storage.

The Kindred Dam alternative would require the relocation of 13 road crossings in the pool area. Because of the minor traffic volume on most of these roads, a number of them could be permanently displaced. This

action would increase transportation distances for the local farmers and ranchers who constitute the main users. A number of these roads may be access roads primarily for area residents who would be displaced by this alternative; therefore, they would no longer be needed following project construction. The Kindred Dam alternative would prevent much of the temporary disruption of major and minor transportation routes which occurs in the West Fargo area during large floods.

The Kindred Dam alternative would have a major effect on community cohesion in the Kindred and West Fargo areas. In the Kindred area, 32 to 57 farmsteads and residences would have to be relocated. Many of these potential acquisitions are family homesteads which have been held for two or three generations, and the feelings of shared community and ties to the land are quite strong. Local public facilities, including churches, cemeteries, and a 4-H camp would also have to be acquired. The readjustment of local community patterns required by these relocations might prove severe. Local opposition to this alternative has been significant since before the reformulation study, and this opposition does not appear to have diminished. The relocation of families in a primarily rural area has a large potential for hardship cases and problems in finding suitable replacement housing and farmlands and ranchlands. The problems could lead to project delays, litigation actions, and increased opposition both to this alternative and the study process as a whole. This alternative might also require special mitigation actions for people relocated by the project, and opposition to the extensive fish and wildlife mitigation land required might arise.

Nevertheless, this alternative would benefit community cohesion in the Horace-West Fargo-Harwood area by encouraging confidence in the permanence of present homesites and full commitment to long-term community problems and plans. The protection from flooding would enhance the viability of the portion of West Fargo that suffers periodic large-scale flooding.

The Kindred Dam alternative would affect community growth in both West Fargo and Kindred. Property tax revenues in West Fargo would probably increase slightly if this alternative were implemented. This additional tax revenue would result from increased property values for flood-prone structures that would be protected by Kindred Dam. However, tax revenues in the Kindred area would decrease because of the relocation of some residents.

The relocation of families in the Kindred area would have an adverse impact on community growth. Kindred functions primarily as an agricultural service center, supplying farmers and ranchers in the immediate area. If, because of the relocation action, a number of those farmers or ranchers were no longer engaged in those pursuits and their lands were removed from agricultural production, the amount of business to retail trades and agricultural service firms would decrease.

The Kindred Dam alternative would benefit public services in the West Fargo area during floods. Benefits would include protection of water supply and sewer systems and transportation routes as well as reduction of the stress placed on fire and police services during floods.

The Kindred Dam alternative would temporarily increase employment in the construction trades. However, any permanent increases in employment would be minor, and this alternative could in fact impose permanent employment losses in agriculture and ranching. Lands bought in fee title for the reservoir storage pool and wildlife habitat mitigation would no longer be in direct economic production. A number of farm workers might no longer be needed.

Depending on the number of local versus nonlocal workers, construction of Kindred Dam could result in an influx of several hundred construction workers and portions of their families. The communities most likely to house these workers would be Kindred, Horace, West Fargo, Fargo, and

possibly the smaller communities within a 20-mile radius of the site. A severe strain could be placed on the facilities and services in the smaller communities. The available housing in these communities would not be sufficient to accommodate the demand created by the influx of workers, and many of these construction families would probably live in mobile homes. Local schools might be negatively affected if increased enrollments exceed school capacities. Fargo and West Fargo are expected to be able to absorb any of these increases because of their larger populations and service structures.

Aside from impacts on schools, housing, and public services, the communities would be expected to undergo little physical change. Experience has shown that most construction "boom towns" rapidly revert to preproject population levels when construction is completed. However, to the extent that smaller communities alter their facilities or service structures to accommodate this transient population, they could be left with oversized and expensive facilities they would be unable to maintain once their populations returned to normal.

The introduction of several hundred construction workers and their families into small towns near the project area could pose a threat to community cohesion. Immigrating workers often introduce new life styles and goals not commonly held by local residents. Controversy resulting from overcrowded schools, strains on local utilities and services, and higher income levels of construction workers might cause considerable resentment in the resident population and initiate conflict both on the local level and between residents and local and Federal governments.

Some of the adverse effects discussed above can be reduced by adequate planning before construction. Any action which would result in a large influx of temporary workers to a primarily rural area should involve planning for these potential problems. A program to absorb these workers should be developed by the agency and the local sponsor if this alternative is implemented.

The Kindred Dam alternative would have significant impacts on social well-being. It would provide a highly acceptable level of flood protection to the lower reaches of the basin. This protection would benefit life, health, and safety by reducing both the structural and economic damages which accompany large floods as well as physical and social impacts (as discussed under the West Fargo diversion alternative). A dam at Kindred, however, would not be equitable in its distribution of costs and benefits between areas. The Kindred area, which would bear the main costs of the alternative (such as residence and farmstead relocations, loss of natural woodland and wetland habitat, relocations of churches and cemeteries, and school district realignments), would gain no major benefit from the action. The West Fargo area, in contrast, would gain the main benefit from Kindred Dam in the form of flood damage reduction benefits to the community, but would bear no significant costs. Educational and recreational opportunities in the Kindred area would also be affected. The alternative would disrupt an existing school district and require new alignments. A 4-H camp would also be acquired. Recreation use in the area might increase if a permanent pool were constructed, but types of recreational activities would change. Recreation associated with the scenic river reach and natural bottomland areas would decrease, while open-water activities associated with reservoir use would increase.

Approximately 4,100 acres of cropland, 7,900 acres of other types of land, and 13,000 acres of fish and wildlife mitigation lands would be required for construction of the 1000-foot elevation flood pool design. The 1010-foot elevation flood pool design would require 5,400 acres of cropland, 10,600 acres of other types of land, and 15,000 acres of fish and wildlife mitigation land. The third design, the 1015-foot elevation flood pool, would require 5,900 acres of cropland, 12,100 acres of other types of land, and 18,000 acres of fish and wildlife mitigation land for construction. The benefited areas along the Sheyenne River would be 50,000 acres of cropland and 1,000 acres of urban land. Land along the Red River of the North would also be benefited.

The 1000-foot elevation flood pool design would sever 11 roads, while the 1010- and 1015-foot elevation flood pool designs would each sever 14 roads.

None of the three designs would reduce flood damages at Valley City or other upstream areas. However, up to 85 percent of the total flood damages at West Fargo and up to 75 percent of the total Sheyenne River flood damages would be reduced by Kindred Dam.

Although these Kindred Dam alternatives would significantly reduce flood levels in the West Fargo area, the amount of reduction for a specific flood would depend in part on the backwater effects from the Maple River and the Red River of the North.

ALTERNATIVES THAT COULD BE MINOR COMPONENTS OF FLOOD DAMAGE REDUCTION PLANS

General

The alternatives discussed in this section were eliminated from further consideration during stage 2 when the evaluation showed that further study was not warranted. The potential contribution of each measure in this group to reducing flood damages, when considered individually, is relatively small.

Continuous Rural Levees: Horace to West Fargo

This alternative would consist of earthen levees on both sides of the Sheyenne River from Horace to the I-94 crossing of the Sheyenne River south of West Fargo. The levees would be offset from the riverbanks for stability and would parallel the meandering river where residential developments occupy the wooded areas near the river. In other areas, the levees would be located away from the river out of the wooded

areas to minimize environmental impacts. The levees would be designed to protect from the 1-percent chance flood with freeboard. However, breakout flows from the Sheyenne River would be allowed to occur upstream of the project area. The levee would be approximately 14 miles long, about 7 miles on each side of the river, and would require several highway and railroad closures.

The first cost of this alternative would range from $4 to $8 million, with the annualized cost at $460,000. An estimated $400,000 in flood control benefits could be credited to reduction of flood levels through the leveed reach. The benefit-cost ratio would be about 0.9. If all breakout flows were confined to the Sheyenne River upstream of Horace, the levees would have to be raised. Also, the confining effect of these levees would prevent some breakout overflows to the Red River of the North, thus possibly increasing flood stages downstream. This effect could be worsened by not allowing breakout flows to occur upstream.

Woodland and cropland would be the dominant types of habitat affected. Approximately 150 acres of riparian woodland and 50 acres of cropland would be required for levee construction. These lands include fish and wildlife mitigation lands.

Water quality impacts would center primarily around turbidity. Turbidity and sedimentation would increase downstream during construction because of equipment movement and placement of fill material. The levees would have a negative aesthetic impact before they were vegetated.

No farmsteads and residences, businesses, or public facilities would be acquired by this alternative. The alternative would benefit about 200 farmsteads and residences.

<u>Continuous Rural Levees: West Fargo to Harwood</u>

This alternative would consist of earthen levees on both sides of the Sheyenne River from West Fargo to the I-29 bridge crossing the Sheyenne

River near Harwood. Tieback levees along the Maple River, lower branch of the Rush River, and Rush River would be necessary to prevent floodwaters from these rivers from entering the protected area. A total of about 35 miles of levees would be constructed, providing protection from the 1- to 2-percent chance floods with freeboard.

The first cost of this alternative would range from $7 to $14 million, with the annualized cost at $670,000. An estimated $520,000 of flood control benefits could be credited to the reduction of flood levels in the leveed reach. The benefit-cost ratio is 0.8. Some increase in flood stages would occur immediately downstream of the leveed area because of the confining effects of these levees and the prevention of overflows into the Harwood Slough area.

Approximately 450 acres of land would be required for construction of this alternative. These lands include 300 acres of cropland and 150 acres of woodland and other types of lands. Fish and wildlife mitigation lands are included in these requirements.

Water quality impacts would center primarily around turbidity and sedimentation, which would increase downstream during construction. Until the levees were vegetated they would have a negative aesthetic impact.

No farmsteads and residences, businesses, or public facilities would be acquired by this alternative. The alternative would benefit 316 farmsteads and residences located between West Fargo and Harwood.

Rural Levees: Selected Reaches from Kindred to the Red River of the North

This alternative would consist of a combination of levees along the Sheyenne River from Kindred to the mouth. It would include primarily those segments of rural levees between Kindred and the Red River of the North that would be most feasible and practical to implement. The levees would

not necessarily be continuous nor would they have to be built on both sides of the Sheyenne River. This plan would enable the construction of a levee system that would use the most beneficial parts of the other levee alternatives discussed. Each minor reach would have to be evaluated as to if, where, and how extensive a levee would be placed. A maximum of approximately 110 miles of levee might be involved. Protection from the 1-percent chance flood would be provided in the residential areas. From 2- to 10-percent chance flood protection could be provided in the rural agricultural areas. The height of the levee would be greatly affected by the amount of breakout overflows that would be allowed. Ensuring breakout flows along the lower Sheyenne River is important to any levee alternative.

The environmental and social effects would depend on the location and type of levee constructed for a particular area. Depending on the acceptability of the various reaches of levees considered, the selected reaches of levees could supplement a major plan for reducing flood damages.

Maple River Diversion (M-6 to Red River of the North)

This alternative would consist of a flood diversion channel to protect the lower reaches of the Sheyenne River in the Harwood area. The diversion channel would start in Section 22 of Raymond Township at about mile 6 on the Maple River and proceed northeast, joining Cass County Drain No. 13 near Argusville and proceeding northeast from there to join the Red River of the North about 3 miles south of Perley. At Maple River mile 6, a diversion structure would be built to divert up to approximately 3,000 cfs from the Maple River through the diversion channel to the Red River of the North. Inlets would be constructed at all drain crossings, and the diversion capacity after each drain inlet would be increased sufficiently to handle the design capacity of the drain. Where the diversion joins the Lower Branch Rush River, an inlet structure would be built for the Lower Branch Rush River, and the size of the diversion channel would be increased to convey a total of 4,000 cfs. The diversion channel would follow the

Lower Branch Rush River until Section 31 of Harwood Township where the diversion channel would separate and proceed north. An outlet structure would be built at this separation point to allow low flows and normal design flows to pass to the east through the Lower Branch Rush River channel. The diversion channel would still be sized to convey 4,000 cfs to the north where it would cross the Rush River in Section 30 of Harwood Township. At the Rush River crossing, a diversion structure would be built to allow low flows and normal design flows to pass on through the Rush River, with the excess plus the diverted flow from the Maple River passing down the diversion to the Red River of the North. The size of the diversion channel would be increased to convey the approximately 5,000-cfs flow from the Rush River crossing diversion structure.

The diversion channel would be approximately 17.9 miles long. The bottom width would range from 50 to 65 feet, with the depth ranging from 10 to 12 feet.

The first cost of the alternative would range from $23 to $28 million, with an annualized cost of $2.0 million. About $500,000 in flood control benefits would be credited to reduction of flood levels in the area downstream of West Fargo. Generally this alternative would be most effective at reducing floods in the reach along the Sheyenne River from West Fargo downstream to the mouth because the Maple River peak and the first peak on the Sheyenne River occur at approximately the same time. Also, this lower reach of the Sheyenne River is greatly influenced by flows and river levels on the Red River of the North. Flood control benefits cannot be specifically defined at this time for the West Fargo area. It is anticipated that this alternative would help reduce flood levels within West Fargo for the first peak; however, these flood levels would also depend on the effects of the flows from the Lower Branch Rush River, Rush River, Maple River, and Red River of the North. Flood levels through West Fargo for the second peak would probably not be affected by this alternative.

The dominant type of habitat affected by this alternative would be cropland. Approximately 220 acres of cropland, 157 acres of grassland, 9 acres of wetlands, and 6 acres of woodland would be affected by this alternative. The most valuable habitat in the lower basin is the riparian woodland. The surrounding area has been classified as prime farmland by the Soil Conservation Service.

The riparian woodlands provide habitat for deer and semiaquatic organisms and are used as a valuable transition area for migrating birds. The woodlands are essential to the wintering deer herds in the lower basin. The woodland loss could be mitigated by plantings along the diversion right-of-way. Enhancement opportunities are available through purchase of permanent instead of temporary easements along the diversion and planting of vegetation or windbreaks. The windbreaks would provide wildlife habitat and could be designed to reduce snow accumulation in the channel.

The effects of noise associated with this alternative would be minimal. Construction activities would be limited to nonresidential and rural areas. Following construction, noise levels associated with operation and maintenance would be negligible. A slight, temporary increase in noise would result from the movement of heavy equipment to and from the construction site and from detoured local traffic.

One farmstead and residence would be acquired becasue of the diversion; however, no businesses or public facilities would have to be acquired. Approximately 600 farmsteads and residences, 12 businesses, and 7 public facilities would benefit from this alternative. Farming practices might be hampered by the diversion because it would cut diagonally across some field sections. Therefore, farmers along the diversion route would lose some portions of their productive farmland.

Construction of the diversion would somewhat alter the aesthetic character of the area. The streambed and banks of the Maple River would remain unchanged. However, the character of the Lower Branch Rush River, Rush River, and County Ditch No. 13 area would be altered. The diversion banks would probably be unsightly before seeding and vegetation. Grass cover would be maintained in the channel. The protection this alternative would afford from flooding could be interpreted as providing a benefit to aesthetic quality because it would prevent the visual deterioration of the area associated with the mud and debris temporarily present following flooding. The diversion could also provide an aesthetic benefit by lessening the deterioration of existing structures in the floodplain that are susceptible to periodic inundation.

The diversion would temporarily interrupt transportation along several gravel roads during construction. Decisions to restore these roads would be based on the frequency of use of the roads. While the roads were closed, access to farmfields would be hampered. Modifications to existing highways and roads during construction could result in some emergency service delays and create additional hazards if traffic rerouting during construction were not handled efficiently. The hazards of major impediments to emergency service delivery or increases in traffic accidents could be avoided through an adequate program of notification of delays or detours, staggered construction of parallel routes, and planned emergency vehicle rerouting. Following construction, the diversion alternative should reduce the stress on emergency service delivery during floods, resulting in better services to those requiring special assistance.

Approximately 1,040 acres of cropland and 240 acres of other types of land would be required for implementation. The lands benefited by this alternative would be 40,000 acres of cropland and 150 acres of urban lands.

No specific reduction in the effects of the 1-percent chance flood in West Fargo can be attributed solely to this alternative. It should be coupled with other alternatives to provide a complete plan. However, the alternative would benefit an area which has few effective options to reduce flood levels. With annualized costs of $2.0 million and annual benefits of $500,000, the benefit-cost ratio for this alternative is 0.25. Additional benefits may be available along the Maple and Rush Rivers.

This diversion would generally affect flood levels along the Red River of the North by less than one-half foot. For some floods, it might decrease flood levels along the Red River and for others it could cause increases, but these changes would be minor.

Enderlin Dam (Maple River Main Stem M-106)

This alternative would consist of an earth fill dam at about river mile 106 on the Maple River about 2 miles northwest of Enderlin in Section 28 of Pontiac Township. The 55-foot-high dam would have a design flood pool elevation about 1130, with a top of dam elevation about 1140. Approximately 33,000 acre-feet of storage would be available for flood control, with the design flood pool affecting approximately 3,800 acres.

The first cost of this alternative would range from $9 to $17 million, with an average annual cost of $960,000. This alternative could significantly decrease flood flows on the Maple River at Enderlin. The structure would have a limited effect on flows in the Sheyenne River below the mouth of the Maple River. Because of its capacity for reducing backwater effects of the Maple River, this alternative could slightly reduce Sheyenne River flood levels at West Fargo. This alternative would have to be coupled with other alternatives that would reduce flood levels for the first and second peaks along the Sheyenne River above its confluence with the Maple River.

The dominant habitats that would be affected by this alternative are grasslands and croplands. Approximately 1,700 acres of grassland and 1,700 acres of cropland would be affected. Approximately 370 acres of wetland and 30 acres of woodland would also be affected. The wetland acres are predominantly ponded areas in the Maple River and may be valuable to waterfowl and riverine species.

Water quality impacts would center primarily around turbidity. Turbidity would increase during construction as a result of movement of equipment and placement of fill.

The fishery of approximately 15 miles of Maple River upstream of the dam could be affected by this alternative. Two farmsteads and residences would have to be acquired. Construction of the dam would temporarily increase noise levels. However, because of the rural character of the area and the distance from people who might be affected, the increases are not expected to have a significant impact on any individuals or groups.

The Enderlin Dam would have no aesthetic impacts on the Sheyenne River or streambed. However, it could have aesthetic impacts on the Maple River because of flood pool fluctuations, influences on groundwater levels, and turbidity.

Approximately 2,500 acres of cropland, 2,500 acres of grassland, and 1,700 acres of other types of land would be required for construction of this alternative. The lands required for construction include fish and wildlife mitigation lands.

Because of the alternative's limited effects on flood flows in the Sheyenne River, reductions in total Sheyenne River flood damages would be correspondingly small. Furthermore, this reduction would apply only to the first peak on the Sheyenne River and would be generally effective only in the reach below the mouth of the Maple River.

Tributary Dams

This alternative would involve reservoir storage on tributaries to the Sheyenne River upstream of Kindred. Twenty-four reservoir sites were evaluated initially. Of these, four warranted more detailed evaluation. However, this evaluation determined that three sites could not be implemented at this time. If these sites were to be developed in the future by Federal, State, or local concerns, consideration should be given to flood control storage because flood control benefits can be derived from reduction of the first peak on the Sheyenne River.

Because of the small size of these structures, a permanent recreation pool may be desired. The North Dakota State Water Commission and Ransom County Water Management District are considering a pool at the Dead Colt Creek site. Dead Colt Creek alternative is the only tributary dam being carried forward. However, use of a permanent pool could reduce storage available for flood control.

A discussion of these reservoirs follows. Figure L-3 shows the locations and table L-5 presents the pertinent data for each tributary dam.

The dominant habitat affected would be grazed grassland. The duration of storage would kill most of the grassland vegetation. Regrowth would consist mostly of weedy species such as thistle, dock, etc. The environmental impacts are summarized in table L-6.

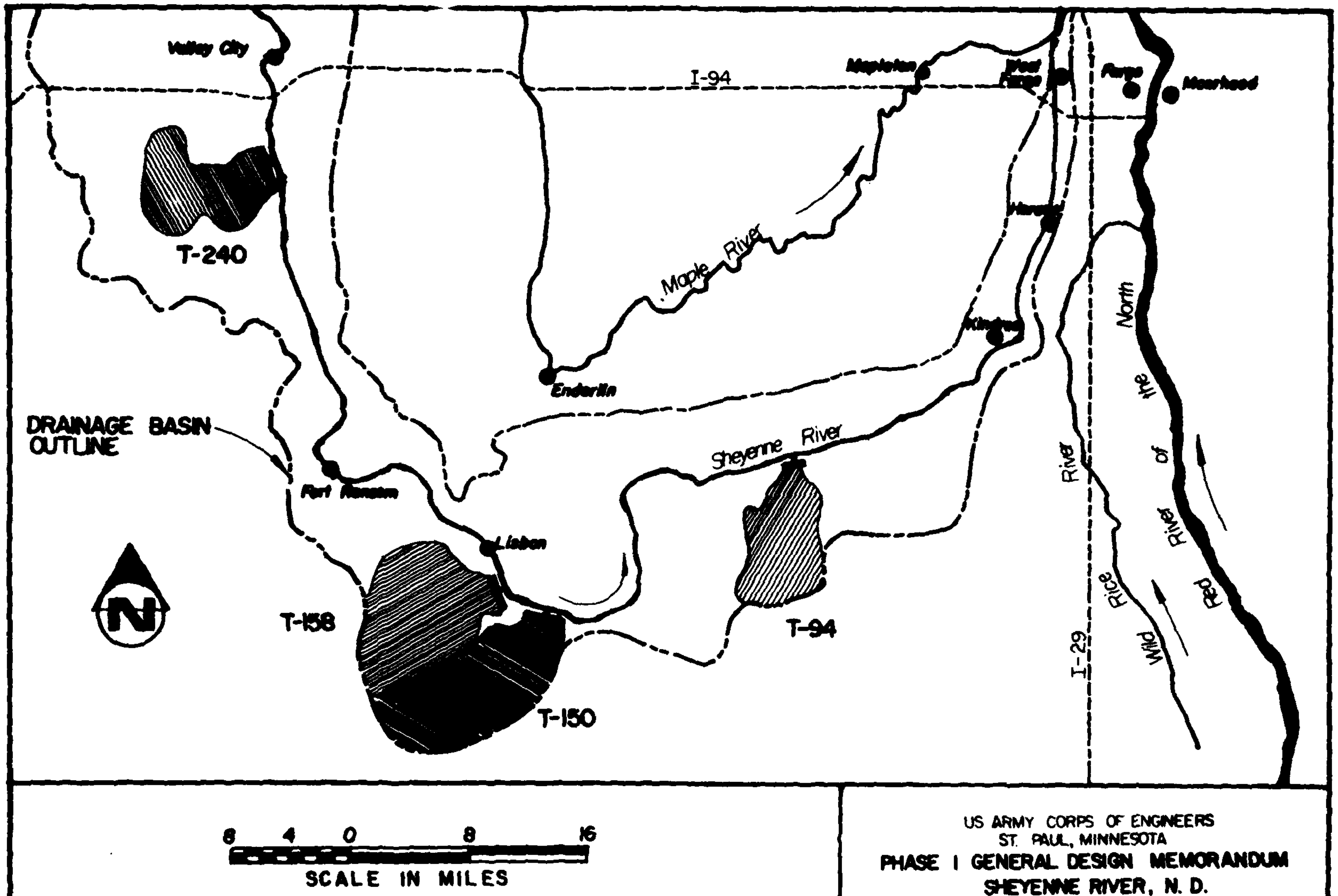
Water quality impacts would center primarily around turbidity. Turbidity would increase during construction as a result of equipment movement and placement of fill. Some of the turbidity may be noticed

in the Sheyenne River. Water storage in the flood pool would result in denuded shorelines and increases in erosion. Turbidity and sedimentation would increase downstream.

Construction of these dams would temporarily increase noise levels. However, because of the rural character of the area and the distance from people who might be affected, the increases are not expected to significantly affect any individuals or groups.

Implementation of these tributary dams would have a minimal adverse impact on potential wild and scenic river designation. The water quality impact of the tributary dams could, however, have some effect on wild and scenic river designation potential. The overall impacts of this alternative on wild and scenic river designation would not be significant.

These dams would have no aesthetic impacts on the Sheyenne River or streambed. The groundwater levels in adjacent areas could be increased if permanent storage pools were used and might change vegetative patterns in these areas. Other aesthetic impacts could result from flood pool fluctuations. After the flood pool receded, the area that was inundated would be unsightly until it was vegetated again.



NOTE: AREA CONTROLLED BY DAM

US ARMY CORPS OF ENGINEERS
ST. PAUL, MINNESOTA
PHASE I GENERAL DESIGN MEMORANDUM
SHEYENNE RIVER, N. D.

TRIBUTARY DAM DRAINAGE BASINS AND STRUCTURE LOCATIONS

JANUARY 1982

Figure L-3

Table L-5 - Pertinent information on tributary dam sites

Item	Site		
	T-94 (Iron Springs)	T-158 (Timber Coulee)	T-240
Pertinent data			
Drainage area (square miles)	40	50	30
Storage capacity (acre-feet)			
Flood control	4,800	5,700	8,000
Conservation pool	(1)	(1)	(1)
Total storage (acre-feet)	4,800	5,700	8,000
Area flooded (acres) at flood pool	300	230	300
Dam			
Type	Earth fill	Earth fill	Earth fill
Elevation, top of dam (feet msl)	1060	1170	1300
Height (feet)	50	70	80
Economics			
Costs			
First cost ($million)	0.6 to 1.0	0.7 to 1.7	1.2 to 2.0
Average annual cost ($1,000)	80	110	140
Flood control benefits ($1,000)	30[2]	100[2]	10[2]
Benefit-cost ratio	0.4	0.9	0.1
Social effects			
Properties acquired			
Farmsteads and residences	0	0	1
Businesses	0	0	0
Public facilities	0	0	0
Properties benefited[3]			
Farmsteads and residences[3]	503	503	664
Businesses[3]	12	12	15
Public facilities[3]	6	6	8
Persons relocated[4]	0	0	3
Persons benefited[3]	1,500	1,500	2,000
Lands required (acres)			
Cropland	250	220	270
Other	440	310	420

Table L-5 - Pertinent information, tributary dam sites (cont)

Item	Site: T-94 (Iron Springs)	T-158 (Timber Coulee)	T-240
Lands benefited (acres)(3)			
Cropland	23,400	23,400	36,400
Urban	100	100	150
Other	--	--	--
Transportation - roads severed	0	0	1

(1) Because of the small size of these structures, a permanent recreation pool may be desired. Such a pool is currently under consideration at the Dead Colt Creek site by the North Dakota State Water Commission. Use of a permanent pool could reduce storage available for flood control.

(2) Flood control benefits would be derived only from reductions of the first peak on the Sheyenne River and would be generally most effective in the reach from Kindred to West Fargo. These small dams must be coupled with other alternatives which would reduce the second peak before they can be considered effective. Benefits are only estimated in the reach from Kindred to West Fargo.

(3) Benefited along the Sheyenne River from near Anselm to just south of West Fargo, except for T-240 which includes the Lisbon area.

(4) Based on the estimate of three persons per residence.

Table L-6 - Summary of impacts associated with tributary dams

Item	Site: T-94 (Iron Springs)	T-158 (Timber Coulee)	T-240
Habitat			
Woodland	About 40 acres affected. Some savannah type habitat also affected. Extensive woodlands of the lower basin are nearby.	30 acres affected.	20 acres affected.
Cropland	No cropland affected.	No cropland affected.	25 acres affected.
Grassland	About 260 acres of grassland affected. Controlled grazing practiced on the land. Good grassland habitat.	200 acres affected.	255 acres affected.
Wetland	Little effect.	Little effect.	Little effect.
Fishery	These spring fed streams are generally of better water quality and provide habitat for forage fish and larger fish that require clearer water (i.e., blackmore dace and northern redbelly dace).	Intermittent stream. Little impact.	Intermittent stream. Little impact.
Miscellaneous			
Rare plants and animals	Possibly affect a rare plant species (sensitive fern). Located in area used by prairie chicken.	None known.	None known.
Water quality	Temporary increase in turbidity caused by construction. Water storage and denuded shorelines could increase erosion and downstream turbidity and sedimentation.		
Aesthetics	The weedy vegetation resulting from temporary inundation would be in contrast to existing prairie grasslands. Weedy vegetation would provide less desirable wildlife habitat and therefore affect wildlife populations. A temporary negative impact would result from construction activities.		
Planning constraints			
E.O. 11988 (Floodplain)	The project would be located in the floodplain.	The project would be located in the floodplain.	The project would be located in the floodplain.
E.O. 11990 (Wetlands)	Little wetland would be affected.	Little wetland would be affected.	Little wetland would be affected.
Preserve riverine environment	Some woodland and the creek floodplain would be lost.	Some woodland and the creek floodplain would be lost.	Some woodland and the creek floodplain would be lost.
Federal threatened and endangered species	None known.	None known.	None known.
Federal and State wild and scenic rivers	Probably not significant. The impacts to water quality as a result of construction and operation of the dams could influence designation potential.		
Areas of critical national importance			
Game management areas, refuges, grasslands, etc.	Portions of Sheyenne National Grasslands affected.	None.	None.
Cultural resources	No known sites are within the flood pool or dam construction area. Three prehistoric site leads are within T-94 drainage subbasin.	One known prehistoric site is within the flood pool. No known sites are within the dam construction area. Four known prehistoric sites and two prehistoric site leads are within T-158 drainage subbasin.	No known sites are within the flood pool, dam construction area, or T-240 drainage subbasin.

T-94 (Iron Springs) - This alternative would consist of an earth fill dam on a tributary to the Sheyenne River at about river mile 94. The tributary, Iron Springs, enters the Sheyenne River from the south about 1 mile east of the Ransom-Richland County line. The dam would be located in Sections 17 and 18 of Sheyenne Township.

The dam would control an area of 40 square miles. The total storage capacity would be 4,800 acre-feet. If a conservation pool were added, the flood control storage capacity would be reduced accordingly. At flood pool, the surface area of the reservoir would be 300 acres.

The first cost of this alternative would range from $0.6 to $1.0 million, with the average annual cost at $80,000. Flood control benefits would be derived only from reduction of the first peak on the Sheyenne River and would be generally most effective in the reach from Kindred to just south of West Fargo. This small dam must be coupled with other alternatives which can reduce the second peak before it can be considered effective. Average annual benefits of $30,000 are estimated in the reach from Kindred to just south of West Fargo. The benefit-cost ratio would be about 0.4.

Iron Springs Dam would inundate portions of the Sheyenne National Grasslands. This area is now used for grazing domestic livestock. The storage duration would probably make the area unsuitable for grazing because of the invasion of less desirable weedy species. The wildlife value of the area would also be reduced for the same reason.

The sensitive fern and prairie chicken are found in the area of this dam. The flood pool would have undesirable effects on these species.

No farmsteads and residences, businesses, or public facilities would be acquired by this alternative. The Iron Springs Dam would benefit 503 farmsteads and residences, 12 businesses, and 6 public facilities located along the Sheyenne River downstream from the dam to just south of West Fargo. Within the same area, about 1,500 persons would benefit from the alternative.

Approximately 250 acres of cropland and 440 acres of other types of land would be required for construction of this alternative. The lands required for construction include fish and wildlife mitigation lands. The lands benefited along the Sheyenne River would include about 23,400 acres of cropland and 100 acres of urban land.

T-158 (Timber Coulee) - This alternative would consist of an earth fill dam similar to those previously discussed. It would be located on a tributary to the Sheyenne River at about river mile 158. The tributary, Timber Coulee, enters the Sheyenne River from the west about 1 mile south of Lisbon. The dam would be located in Section 33 of Island Park Township.

As shown in table L-5, the dam would control a drainage area of 50 square miles. The total storage capacity would be 5,700 acre-feet. If a conservation pool were added to this design, the flood control storage capacity would be reduced. At design flood pool the surface area of the reservoir would be 230 acres.

The first cost of this alternative would range from $0.7 to $1.7 million, with an average annual cost of $110,000. Average annual flood control benefits of about $100,000 could be gained from reduction of the first peak on the Sheyenne River and would be most effective generally in the reach from Kindred to just south of West Fargo. This small dam would have to be coupled with other alternatives that would reduce the second peak before it can be considered effective. The benefit-cost ratio would be about 0.9.

Approximately 220 acres of cropland and 310 acres of other types of land would be required. All of these lands include fish and wildlife mitigation lands. The lands that would benefit include about 23,400 acres of cropland and 100 acres of urban land.

About 1,500 people, 503 farmsteads and residences, 12 businesses, 6 public facilities along the Sheyenne River would benefit.

T-240 - This alternative would consist of an earth fill dam similar to those discussed above. The dam would be located on a tributary to the Sheyenne River at about river mile 240. The tributary enters the Sheyenne River from the west about 6 miles south of Valley City, North Dakota. The dam would be located in Section 33 of Marsh Township.

The dam would control a drainage area of 30 square miles. The total storage capacity would be 8,000 acre-feet. If a conservation pool were added to this design, the flood control storage capacity would be reduced. At design flood pool, the surface area of the reservoir would be 300 acres.

The first cost of this alternative would range from $1.2 to $2.0 million, with an average annual cost of $140,000. Flood control benefits would be derived only from reduction of the first peak on the Sheyenne River. The alternative would be most effective in the reach from Kindred to just south of West Fargo. This small dam would have to be coupled with other alternatives that would reduce the second peak before it could be considered effective. Benefits are only estimated in the reach from Lisbon to just south of West Fargo. On the basis of the above information, only about $10,000 in flood control benefits are estimated.

This alternative would benefit about 664 farmsteads and residences, 15 businesses, and 8 public facilities located along the Sheyenne River from Lisbon to just south of West Fargo. Within this area, about 2,000 persons would benefit from the alternative's reduction capabilities.

Approximately 270 acres of cropland and 420 acres of other types of land would be required. The lands include the fish and wildlife mitigation land. The lands that would benefit include about 36,400 acres of cropland and 150 acres of urban land. No guaranteed reduction can be attributed to this alternative alone because it must be coupled with other alternatives which would reduce the second peak.

The average annual cost of the tributary dam is estimated at $140,000, and the total average annual benefits are estimated at $10,000, resulting in a benefit-cost ratio of 0.1.

ALTERNATIVES CONSIDERED DURING STAGE 3

GENERAL

The flood damage reduction alternatives retained for consideration in stage 3 are discussed in this section. These alternatives are grouped into three categories: (1) those which are part of the existing condition and/or should be considered as part of the future base condition, (2) those which could be considered as major components of a flood damage reduction plan, and (3) those which could be considered as minor components of a flood damage reduction plan. The alternatives are grouped into these categories in table L-7.

Table L-7 - Summary of alternatives considered during stage 3

Alternative	Status of further consideration: Part of existing and future condition	Major component of flood damage reduction plan	Minor component of flood damage reduction plan
Nonstructural			
Basinwide drainage plan	X		
Regional/basinwide water planning	X		
Develop out of floodplain			X
Better land use planning	X		
Floodplain zoning	X		
Floodplain regulations	X		
Control private levee construction	X		
Enforce drainage laws	X		
More stringent legislation to control drainage			X
Financial incentives to retain water on farmland			X
Small retention dams			X
Provide flood insurance	X		
Relocate frequently flooded structures			X
Flood proofing			X
Revised management of Baldhill Dam			X
Flood forecasting and emergency measures	X		
Structural			
Levees			
Ring levees at farmsteads, residences and small developments			X
Diversions			
M-29 to M-24, levees and diversion around West Fargo		X	
M-42 to M-24 via Drain No. 21		X	
Drainage ditches, bridges, etc.			
Enlarge Cass County Drains Nos. 13, 21, and 45			X
Install retention control structures on drains			X
Modify bridges and highways			X
Snag and clear Sheyenne River			X

Table L-7 - Summary of alternatives considered during stage 3 (cont)

Alternative	Status of further consideration: Part of existing and future condition	Major component of flood damage reduction plan	Minor component of flood damage reduction plan
Wetlands			
Restore drained wetlands			X
Increase storage capacity of wetlands			X
Dams and reservoirs			
Sheyenne River - main stem			
Baldhill Dam (M-271)		X	
Sheyenne River - tributaries			
Dead Colt Creek (T-150)			X

The information presented in this section is generally more detailed than that presented in the previous sections; however, the information is still preliminary and subject to revision after further evaluation. Economic figures for these alternatives are at October 1981 levels. The information is based on each alternative working independently and is meant to indicate where the alternative would be effective and describe its relative effectiveness compared with other alternatives. However, the true effectiveness of an alternative can be measured only when that alternative is considered as part of a plan. The plans are discussed in Appendix M, Plan Formulation.

ALTERNATIVES THAT ARE PART OF THE EXISTING AND/OR FUTURE BASE CONDITION

Those alternatives that already exist and, based on current trends, are expected to continue or which may not now exist but, based on current trends, can be projected to be in effect in the future are the types of alternatives in this category. Measures in this group have a wide variety of effects on flooding and flood damages. The relationship of these measures to flooding and flood damage reduction and the advantages and disadvantages of the measures are discussed in the following paragraphs.

Basinwide Drainage Plan

A basinwide drainage plan based on sound hydrologic and hydraulic analyses and exhibiting an understanding of its social, environmental, and economic consequences would assist in orderly and rational implementation of future drainage. A more complete understanding of the relationship of drainage to downstream flood flows and damages would be essential. Control over drainage currently rests with the water management districts and North Dakota State Water Commission on drainage projects that involve an upstream watershed area larger than 80 acres. A coordinated approach

at the water management district level would be essential in the development and implementation of a basinwide plan. Such a plan would help reduce adverse effects on downstream flood prone areas that might result from future drainage projects.

Water management districts are generally set up on a county-by-county basis rather than by watershed boundaries. This arrangement makes it very difficult to develop or implement a basinwide plan because it relies on the uniform compliance and enforcement of a drainage policy from one county to the next. However, in large watersheds, such as the Sheyenne River basin, the water management problems of downstream counties are different from the water management problems of upstream counties; yet the problems are interrelated because how water is managed in one county can directly affect another. A change of organizational jurisdiction of the water management districts to watershed boundaries rather than county boundaries would permit more effective development and implementation of a basinwide plan. Development of criteria to approve or disallow drainage would be an essential first step in the control of unwise drainage.

Regional/Basinwide Approach to Water Planning

The regional/basinwide approach to water planning is instrumental in the development of water resources to serve the maximum number of people. Needs of specific communities and/or individuals may be more efficiently met if they can be dealt with by a joint effort. Recognition of the beneficial and adverse effects of any given water resource need and/or development project is instrumental to the need or project being met or implemented. Major water user needs go beyond local boundaries and may require development of water projects in areas where the disruption of the existing environmental setting and life-style are not desired. The regional population must understand and agree with the needs and solutions being developed to allow for orderly implementation of a major water resource development project.

Using the regional approach to water planning would not exclude the development of small projects for any given community, but would establish the relationship of that project to the other areas of the region, displaying areas of benefits, areas of adverse effects, and areas of no effects.

Better Land Use Planning

Land use planning implies that control over land use rests with governing bodies. Better land use planning implies that existing controls are not sufficiently restrictive and should be made more restrictive. The degree to which land use controls should be made more restrictive depends on which level of government should have the most control. Township, county, and city governments are more responsive to local needs and are concerned with improving the living standards for their people. State and Federal levels of government are generally less responsive to local needs and more responsive to regional, State, and national needs. If better land use planning implies that conservation of the land resource should be emphasized and that the land be put to its most productive use, then moving the land use control to the regional, State, or Federal level may offer the best potential to achieve this goal. Shifting from local to regional or a higher level of government control would be a significant change in the existing structure of land use controls.

Without a major shift in land use controls to a higher level of government, land use planning at the local level could be improved by adding planning staff to assist local decision makers in adopting plans that emphasize conservation of the land resource and dedication of the land to its most productive uses.

Floodplain Zoning

Enactment and enforcement of floodplain zoning would consist of adoption by the cities and townships (or the county in lieu of the townships) of ordinances which govern the construction of buildings and other development in the floodplain. Subsequent enforcement of the ordinances would be necessary to ensure that the objectives of the zoning are being achieved.

Properly developed and enforced floodplain zoning laws can significantly reduce the growth of future flood prone development. As a result of the Flood Disaster Protection Act of 1973, States and local communities, as a condition of future Federal financial assistance, are required to participate in the Federal flood insurance program and adopt adequate floodplain ordinances with effective enforcement provisions consistent with Federal standards to reduce or avoid future flood losses. The existence and enforcement of these floodplain ordinances are assumed in the evaluation of Federal flood damage reduction projects, including the studies being conducted on the Sheyenne River.

Floodplain Regulations

Building codes, zoning, and other permitting and land use controls are combined in floodplain regulations. Adequate floodplain regulations would reduce the growth of future flood prone development. All alternatives being evaluated in the Sheyenne River study assume that adequate floodplain regulations are in effect.

Control of Private Levee Construction

Private levees have been constructed at many locations along the Sheyenne River. In many instances, the levees have protected a property owner from flood damages. However, in some cases, these levees

worsen flood conditions for neighboring property owners. The levees in the reach between Kindred and Horace could increase flood levels in this reach and downstream, including West Fargo. During large floods, a substantial amount of floodwater from the Sheyenne River between Kindred and Horace flows overland to the Red River, Wild Rice River, and County Drain 21 system. If levees prevented these overflows, flood damages in downstream areas along the Sheyenne River could increase. Therefore, care and consideration should be exercised in the construction of levees. The potential adverse effects should be accounted for before levees are constructed or raised.

Authority for control of private levee construction rests with the North Dakota State Water Commission and water management districts. Development of criteria to approve or disallow construction or raising of existing private levees would be an essential first step in the control of unwise levee construction.

Enforcement of Existing Drainage Laws

Existing drainage laws require a permit before an area with a watershed larger than 80 acres is drained. Drainage laws in various forms have existed in North Dakota for about 70 years. In the most recent change (1977), the State legislature relaxed permit requirements. Before that change, a permit was required to drain areas with watersheds as small as 40 acres.

The State Water Commission and water management districts issue permits and enforce drainage laws. Criteria for issuing permits have been established by the State Water Commission. Essentially, if the area to be drained has unique fish and wildlife values or could increase flood damages downstream, the permit may be disallowed. The determination of which drains may potentially affect flood stages is a key element in this issue. Allowing only

those areas to be drained which do not affect downstream flooding or allowing drainage with sufficient gated controls and operating plans so that downstream flooding would not be worsened is a key step in reducing or minimizing future increases in flood damages.

Flood Insurance

The flood insurance program is administered by the Federal Insurance Administration. It is designed to provide individual property owners who suffer flood damages a way to recover their financial losses at a nominal insurance premium. Under this program, communities are required to adopt and enforce adequate floodplain regulations. The actual cost of flood insurance is quite high; however, the Federal Government subsidizes the premiums and the property owner pays a nominal amount.

Flood insurance does not prevent flood damages; it spreads the flood loss over a wider segment of the population. Flood insurance provides individuals a means of recovering from the financial damages to their dwellings. In conjunction with an adequate floodplain regulation program, the flood insurance program can help reduce the growth of future flood damage potential.

Flood Forecasting and Emergency Measures

Flood forecasting services are provided by the National Weather Service for the Sheyenne River at points in Valley City, Lisbon, Kindred, and West Fargo. The Corps of Engineers and the U.S. Geological Survey cooperate with the National Weather Service in the collection of basic data and in the observation of river conditions throughout the basin to assist in improving the reliability of the forecasts. Communities, State and Federal agencies, and individuals have used the flood forecasts in the past to take mergency preventive measures to reduce flood damages. These emergency measures have included the hurried construction of sandbag and earthen levees, the moving of furniture to higher levels within the dwelling, and other short-term measures.

Continued flood forecasting is essential to the basin even if no other flood damage reduction measures are implemented because it is essential to know how much water and when it will be coming if one is to try to prevent damages from occurring. The construction of emergency levees or other actions during or preceding a flood can often be successful in reducing flood damages for a specific event if enough advance warning is provided and if a plan is available which can be implemented in a short period of time. On a long-term basis, however, the flood emergency approach may reduce some damages but cannot be counted on to provide a reliable reduction in flood damages. As future actions take place, the flood forecasting and flood emergency services will need to be modified to respond to the needs of the basin.

ALTERNATIVES THAT COULD BE MINOR COMPONENTS OF FLOOD DAMAGE REDUCTION PLANS

General

The alternatives discussed in this section could contribute to flood damage reduction. When considered individually, they would make a relatively small contribution. Some of these measures may be important components of an overall plan if used in appropriate combinations. Individual measures could be implemented independently of an overall plan, depending on their specific merits; however, they could also be used to increase the degree of protection provided by a comprehensive plan.

Location of Development Out of the Floodplain

Future developments would have to be built in nonfloodplain areas. The communities, counties, and townships would be the local entities involved in the adoption and implementation of this plan. The Sheyenne River valley is narrow, approximately 1/2 to 1 mile wide, in the Valley City-Lisbon area. But is very wide, if in fact definable, where it joins the old Lake Agassiz bed, ranging from 2 to 4 miles wide in the Kindred-West Fargo area, and the floodplain of the Sheyenne River joins the floodplains of the Maple, Wild Rice and Red Rivers so that the overall floodplain is very large.

Where the floodplain is relatively narrow, the plan would not isolate the new development from existing flood-prone development in the floodplain. Where the floodplain increases in width, implementability becomes increasingly more difficult because the distance between new developments and existing services would increase and services would have to be extended to the new development. These distances and costs would have to be compared to the costs for flood proofing new developments that would be located in the floodplain as well as the damage that could result if no flood proofing were undertaken.

In the West Fargo area, where the floodplain is very wide, new development would be limited to the nonfloodplain area between West Fargo and Fargo or would be forced to move into the Casselton area, 10 miles to the west, or into Minnesota, 7 miles to the east. Ultimately, the nonfloodplain lands between West Fargo and Fargo will probably be fully developed as the two communities grow and become a continuous urbanized area. Some nonfloodplain lands in the Moorhead area will also probably be developed in the future. The policy of development out of the floodplain is certainly wise from the objective of reducing flood damages; however, the other costs of development must and will play an important role in the location of new development. Wise development can take place in floodplain areas if the necessary precautions are exercised.

More Stringent Legislation to Control Drainage

This alternative would involve the enactment and enforcement of stricter legislation to control drainage in North Dakota. As mentioned above, laws concerning drainage have existed in North Dakota for many years. Permits are required to drain areas with watersheds larger than 80 acres.

The size of the area to be drained can be important in determining effects on downstream flood flows. However, other factors, such as the method of drainage, the location of the area to be drained, the land use of the drained area, determine whether drainage will adversely affect downstream flood flows.

Legislation is important in establishing authority for control of drainage and such legislation does exist. Enforcement of existing legislation is as important as stricter legislation. However, proper enforcement would require a commitment of funds, resources, and personnel which is as important as the legislation itself. Stricter legislation to control drainage coupled with rigid enforcement could help stop future increases in flood damages. Implementation of this legislation would be at the State and water management district levels.

Financial Incentives to Retain Water on Farmland

A State or Federal program would be established to provide financial incentives for landowners to retain water on farmland. An effective program would be difficult to develop. It would be somewhat comparable to enforcement of drainagé laws. Financial payments should be based on the potential benefits to downstream areas. This program might help reduce flood flows in some areas; however, it would have to be widely accepted and used before any effects would be felt downstream. Not all farmland is

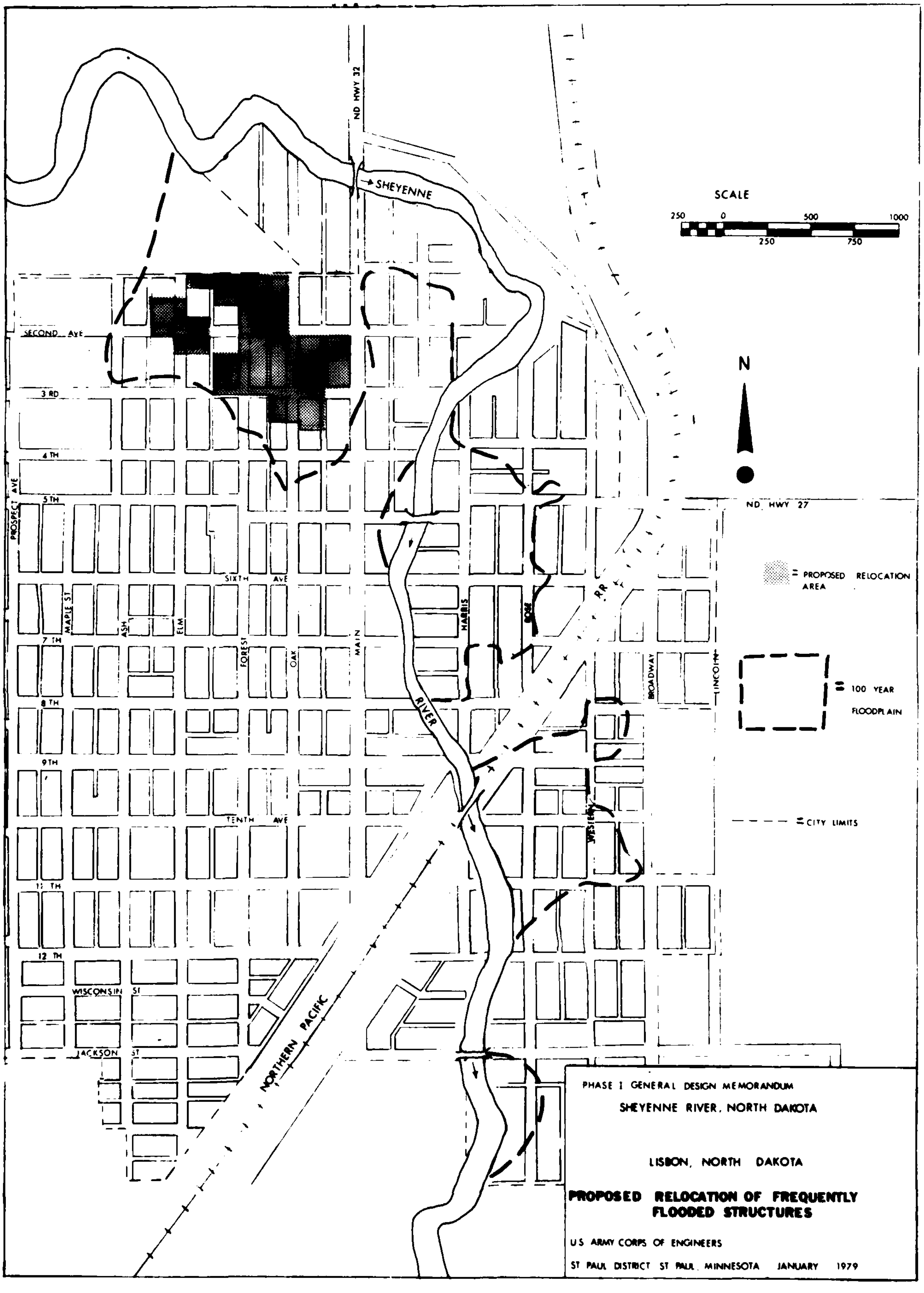
capable of reasonably holding its snowmelt or rainfall runoff. Even with complete holding of water on farmland where it could reasonably be accomplished, substantial uncontrolled drainage areas would still produce significant flood flows and damages. A program such as this could only be considered as a supplement to other major steps taken to reduce flood damages.

Small Retention Dams

Property owners would be encouraged to construct small floodwater retention dams on their properties. This program would be similar to the program described in the preceding paragraph. Financial assistance would be based on downstream benefits. Not all property owners would be able to construct retention dams. Those who do would have to control the release from the dams so that flood peaks downstream would not be worsened by inappropriate timing of the releases. These dams would have to be designed for floodwater retention and would probably not have very large permanent water storage capacities. A large amount of uncontrolled drainage area would still remain, and this area would still produce major floods.

Evacuation of Frequently Flooded Structures, Lisbon and Valley City

Floodplain structures which were or would have been affected by the 1966 flood in Lisbon and Valley City would be evacuated. The recurrence frequency of the 1966 flood at Lisbon is a little less than the 10-percent chance flood; the frequency at Valley City is a little greater. At Lisbon and Valley City, the Sheyenne River valley is anrrow, and the area affected by the 1966 flood contains only a portion of the floodplain structures because the elevation difference between the 10-percent and 1-percent chance floods is several feet. The areas proposed for evacuation in Lisbon and Valley City are shown on figures L-4 and L-5, respectively.


SHEYENNE
ND HWY 32
SCALE
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250 750
N
ND HWY 27
= PROPOSED RELOCATION AREA
= 100 YEAR FLOODPLAIN
= CITY LIMITS
SECOND AVE
3 RD
4 TH
5 TH
PROSPECT AVE
SIXTH AVE
MAPLE ST
ASH
ELM
FOREST
OAK
MAIN
HARRIS
ROSE
BROADWAY
LINCOLN
7 TH
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RIVER
RR
TENTH AVE
WESTERN
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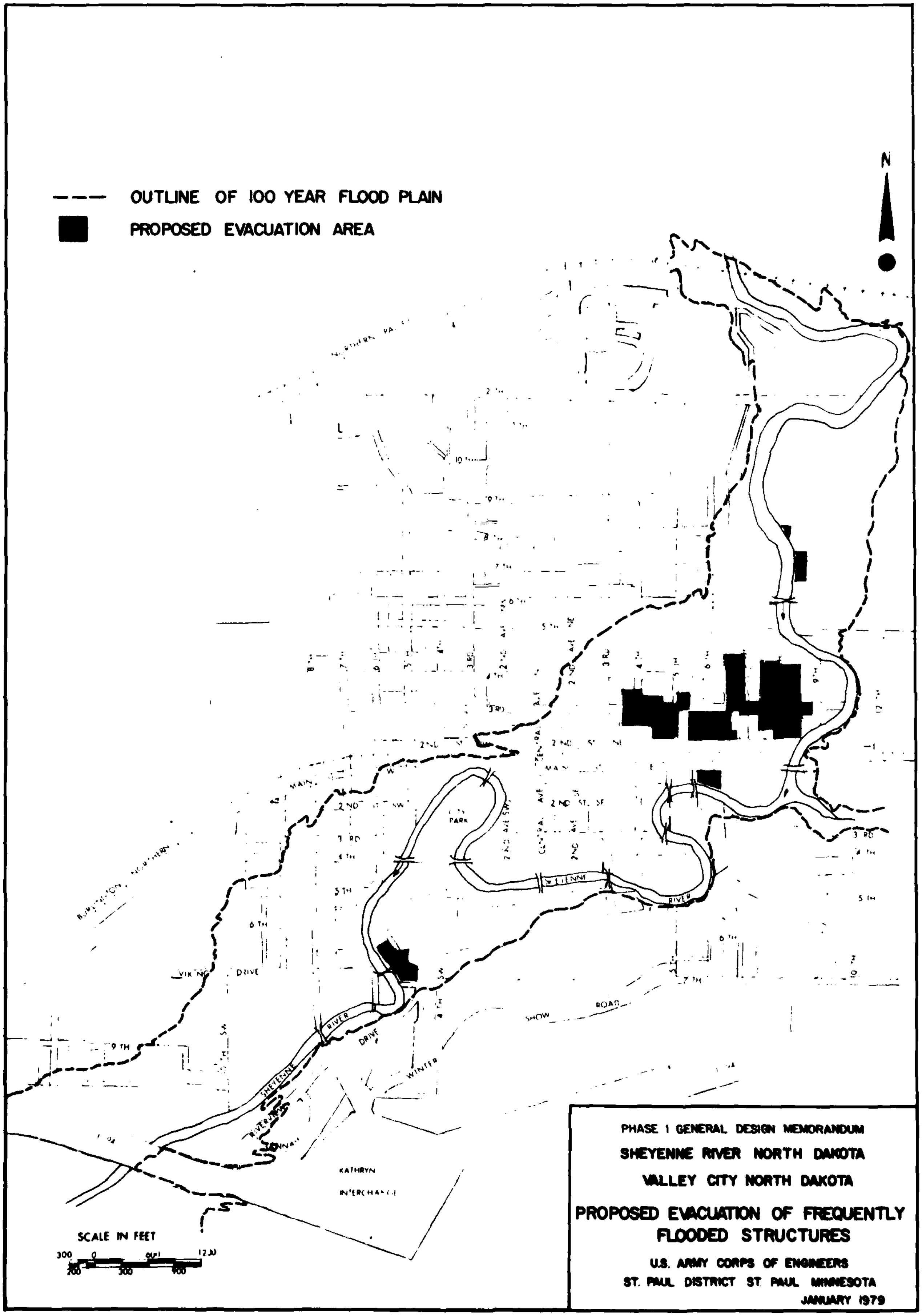
WISCONSIN ST
JACKSON ST
NORTHERN PACIFIC
PHASE I GENERAL DESIGN MEMORANDUM
SHEYENNE RIVER, NORTH DAKOTA
LISBON, NORTH DAKOTA
PROPOSED RELOCATION OF FREQUENTLY FLOODED STRUCTURES
US ARMY CORPS OF ENGINEERS
ST PAUL DISTRICT ST PAUL, MINNESOTA JANUARY 1979

FIGURE L-4



PHASE 1 GENERAL DESIGN MEMORANDUM
SHEYENNE RIVER NORTH DAKOTA
VALLEY CITY NORTH DAKOTA

PROPOSED EVACUATION OF FREQUENTLY FLOODED STRUCTURES

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT ST. PAUL MINNESOTA
JANUARY 1979

FIGURE L-5

Evacuation of flood-prone structures from floodplain areas is generally one of the most effective means of reducing flood damages to residential and commercial developments. However, it is not always an implementable plan for a variety of economic, environmental, and social reasons. Suitable locations for relocation must be available, and the impacts on the community must be at an acceptable level.

In all, 36 residences at Lisbon and 87 residences at Valley City were considered for evacuation. No businesses or public facilities in the 1966 floodplain were considered. Not all structures within the 1966 floodplain would be removed because some structures would not be materially affected by that flood level.

The first cost of this alternative would range from \$1.3 to \$3.2 million at Lisbon and \$3.9 to \$5.8 million at Valley City. The average annual cost for the evacuation would be \$170,000 and \$370,000, respectively. No flood control benefits would be gained anywhere other than in the cities. Therefore, \$60,000 and \$345,000 in flood control benefits can be credited at Lisbon and Valley City, respectively. Table L-8 summarizes the costs and impacts of this alternative.

Table L-8 - Evacuation of frequently flooded structures, Valley City and Lisbon

Item	Valley City	Lisbon
Pertinent data		
Design flood (year)	1966	1966
Recurrence frequency (percent)[1]	10	10
Economics		
Costs		
First cost ($million)	3.9 to 5.8	1.3 to 3.2
Average annual cost ($1,000)	370	170
Flood control benefits ($1,000)		
Valley City	345	-
Lisbon	-	60
Benefit-cost ratio	0.9	0.4
Environmental effects		
Woodland		
Acres	-	-
Percent of total affected	-	-
Grassland		
Acres	-	-
Percent of total affected	-	-
Wetland		
Acres	-	-
Percent of total affected	-	-
Cropland		
Acres	-	-
Percent of total affected	-	-
Mitigation lands required	-	-
Miles of river affected	0	0
Rare species affected	No	No
Threatened and endangered species affected	None known	None known
Areas of national importance affected	No	No
Wild and scenic river affected	No	No
Additional land affected by infrequent flood events	-	-
Aesthetic qualities affected	No	No
Social effects		
Properties acquired		
Farmsteads and residences	87	36
Businesses	-	-
Public facilities	-	-

Table L-8 - Evacuation of frequently flooded structures, Valley City and Lisbon (cont)

Item	Valley City	Lisbon
Social effects (cont)		
Properties benefited		
Farmsteads and residences	87	36
Businesses	-	-
Public facilities	-	-
Persons relocated(2)	261	108
Persons benefited(3)	261	108
Lands required (acres)		
Cropland	-	-
Urban	10	10
Other	-	-
Lands benefited (acres)		
Cropland	-	-
Urban	10	10
Other	-	-
Transportation - roads severed	0	0
Flood damage reduction effectiveness		
Flood damages reduced (percent)		
Valley City	20	0
Lisbon	0	20
1-percent chance flood level reduced		
Valley City	0	0
Lisbon	0	0

(1) The 1966 flood for Valley City is a little more frequent than the 10-percent chance flood, and for Lisbon a little less frequent than the 10-percent chance flood.
(2) Based on approximately 3 persons per residence.
(3) Benefited by reduced flood damages.

This alternative would have little if any impact on the environment because no woodland, grassland, wetland, cropland, or river reaches would be affected.

On the basis of an average of 3 people per residence, 108 and 261 persons would be relocated at Lisbon and Valley City, respectively. However, these people would benefit from reduced flood damages. Further study is needed to determine the full social costs of these relocations. The following points should be addressed in that study:

1. Distributional equity is relatively high for this alternative, in the sense that those receiving the benefits of reduced flooding would also pay the cost of social disruption as they move to new homes or neighborhoods.

2. The financial burden would be borne by the local sponsors (and the taxpayers at that level of government) and the Federal Government rather than the families who would benefit economically. Details of cost-sharing arrangements must be determined, and the fiscal capability of local government must be analyzed.

3. The socioeconomic composition of the relocated population is currently unknown; this information is needed to determine what segment of the community would receive flood damage reduction assistance.

4. The availability of safe, sanitary, and decent replacement housing must also be determined. If the families whose homes were acquired could buy back their own homes and move them out of the floodplain, they would need to purchase suitable land for which roads, utilities, and sewer service must be provided.

5. Acceptability of this alternative within the community as a whole, and especially among those being relocated, would be important to the implementability of the alternative.

6. Besides the financial implications already discussed, the perceptions of community cohesion would affect the level of local acceptability. Do these people want to be moved? What would happen to the neighborhood they move out of and to the neighborhood they move into?

7. For Lisbon and Valley City as a whole, the alternative would reduce economic and behavioral damages by measurable amounts.

8. Less easily quantified, but also important, would be the accompanying changes in institutional relationships, such as zoning law changes, actual land use changes, new or expanded ties to State and Federal agencies, and a lessened reliance on previous flood-fighting groups and assisting agencies.

Approximately 10 acres of urban land is contained in the evacuation areas for both Lisbon and Valley City. These same land areas would be benefited by reduced flood damages. A 20-percent reduction in total flood damages could be achieved at both Lisbon and Valley City.

Flood Proofing

This alternative would consist of structural modifications to existing structures, measures and techniques applied to new structures as they are built, and ring levees around farmsteads and residences in rural areas. Typical flood proofing measures include raising first-floor levels above the regulatory flood level; raising electrical connections, furnaces, and similar items above flood levels; installing check valves on drains; and installing watertight doors and window closures.

Whenever flood proofing is undertaken, access to the flood proofed building, farmstead, or residence could be limited, creating emergency service problems. Also, flood proofing measures are generally most practical where flood depths are not great, water velocities are low, and the duration of the flood is short.

Revised Management of Baldhill Dam

The Baldhill Dam operating plan could be revised by modifying the rates of discharge, the time of drawdown, and/or the levels at which the pool is maintained for the various purposes. The present operation of the dam is based on current lake levels and storages and anticipated spring runoff. The project was designed to ensure supplements for low river flows. However, because most of the basin floods occur in the spring from a combination of snowmelt and rainfall, the lake level is lowered in the winter in anticipation of this annual runoff to store a portion of the floodwater and to reduce flood damages downstream. At the end of the spring runoff, the lake should be back at the normal permanent pool elevation of 1266. Throughout the summer, a full pool is maintained. In the fall, a release schedule is set up to draw the pool level down to 3-1/2 feet below normal pool by the first of March, thus making at least 25 percent of the total storage of 68,000 acre-feet available for flood control. With normal spring runoff, the pool should be refilled by May. However, in years when the snowpack is heavier than usual and high spring flows are anticipated, the level of Lake Ashtabula is lowered by as much as 5 feet more. In 1967, 1969, 1971, 1974, and 1979, the pool level was lowered below the normal 3-1/2 foot drawdown level. Each winter, meetings are held with interested parties to review the status of the pool level and discuss the outlook for lake level operation for the coming year.

To improve dam operations in terms of flood control, the two most likely methods of modifying the management would be either (1) to increase the amount of drawdown and provide more flood control storage, or (2) to modify the rates of discharge during floods and provide the greatest reductions at peak inflows. The distribution of storage in the lake is of prime importance to an increase in the amount of flood control storage through greater drawdowns.

The distribution of the water within Lake Ashtabula is similar to an inverted triangle. Storage per foot of lake level at the top of the pool is much greater than at the bottom. Of the 68,000 acre-feet of

water normally stored, 50 percent is in the top 7-1/2 feet, and the other 50 percent in the lower 20-1/2 feet. Because of this storage relationship and because most floods occur from spring snowmelt runoff, increasing the drawdown of the pool level below the normal 3-1/2 feet by the first of March could provide additional storage for most floods. However, for large floods, the ability of the existing Baldhill Dam to reduce flood flows is very limited because of the relatively small amount of flood storage compared to the volumes of flood inflow.

The revised management of Baldhill Dam could be quite similar to the present operation. On the basis of normal spring runoff, lowering of the lake would begin on 1 October at a rate that would lower the lake level 6 feet (to elevation 1260) by 1 March. This procedure would make almost 40 percent of the total storage available for normal flood control. However, when higher than normal spring flows are anticipated, the lake could be drawn down to elevation 1252. About 75 percent of the 68,000 acre-feet of storage would be available for flood control. These larger drawdowns could jeopardize the refilling of Lake Ashtabula to the normal elevation of 1266 if the anticipated snowfall and snowmelt runoff did not actually occur. Under the existing operating plan, the normal lake level of 1266 was not reached in 1959, 1963, 1973, and 1977. However, the lake level was within 1 foot of normal except in 1977 when the lake level was about 2 feet low. With the revised operating plan, the normal pool level would not have been reached in several other years as well.

This alternative could have impacts on fish, water quality, and lake-shore erosion. The major impacts on fish and wildlife appear to be on the fishery. Continuous yearly drawdowns to elevation 1257 and an occasional drawdown to elevation 1252 would increase the potential for winter fish kills. For example, during the winter of 1978-79, a partial fish kill resulted from low dissolved oxygen levels at the end of the winter. The kill was caused by the unusually long winter and the drawdown to about elevation 1257. Dissolved oxygen levels in the lake are normally lower in the winter. Drawdowns to elevation 1252 would greatly increase the probability of winter fish kills because they would reduce the size of the pool, concentrate the fish in a smaller area, and trap fish in isolated pools or bays. Less oxygen would be available, and the likelihood of fish

kills would increase. More frequent fish kills would adversely affect the recreational fish harvest and the quality of the recreational experience for visitors. It is questionable if the fishery would even survive a single drawdown to elevation 1252. The effects of repeated exposure to low oxygen levels and crowding by drawing the lake down to elevation 1252 would certainly be adverse.

Lake Ashtabula maintains a fair fishery because of the State Game and Fish Department stocking program. Fish stocked in the reservoir (northern pike or walleye) generally require 3 to 4 years to reach maturity. Depending on the frequency of drawdowns to elevation 1252 and winter fish kills, the recreational fishery of the reservoir might be greatly reduced or eliminated. Rough fish are usually more tolerant of low oxygen. Therefore, an increase in rough fish and a decrease in game fish could be expected.

Increased drawdowns could also create situations where water levels could not return to the conservation pool elevation of 1266 feet. The quality of the water-oriented recreational experiences of visitors would be adversely affected. Also, releases from the reservoir would have to occur during the late fall and winter when outflow from the reservoir is usually low. Although this increased release might improve water quality and the fishery downstream, it might also increase ice jam problems. The winter drawdown could cause dangerous ice conditions by creating air pockets beneath the ice producing safety hazards and reducing winter recreational use.

None of the plants on the Federal list of threatened or endangered species are found in North Dakota. However, the State's list of rare plants contains two species found adjacent to Lake Ashtabula: a sedge and a pondweed. The effect on these species is not known.

North Dakota has some State GMA's and game refuges near Lake Ashtabula. If lake levels undergo major changes or if the lake does not return to normal pool level, the vegetation cover needed by some wildlife in the area for nesting, feeding, mating, resting, and access to water could be affected.

Under the revised management plan of lowered pool levels, water supply would be subject to some risk. The risk depends on precipitation each year and is therefore essentially indeterminable. Although the lake contains ample water for 1, 2, or more years for water supply, if the lake were at a lower than normal level entering an extended drought of 3 or more years, the certainty of water availability could be reduced. Although under the revised plan water would be adequate to meet extraordinary water demands in any single year, if a severe drought were to continue for several years, the amount of water available in Lake Ashtabula would be exhausted sooner than under the revised operating plan. At one time, concern about the availability of water was a dominant political issue in the region. This concern was rekindled during the dry period 1976-1977. It is not known how active this topic is at present, but it would probably be more widely discussed if this alternative were implemented, regardless of the actual increased risk.

In addition to the cost of actual and perceived risk of water supply shortages, other social costs would be incurred by residents and recreational users of the lake. These costs would result from the possible biological consequences of the earlier and larger winter drawdown. Depending also on the weather conditions each winter, fish kills could be extensive. Since it takes several years for the stocked fish to mature, a negative impact on recreation could result. The availability of up to 14,000 acre-feet of extra storage for floodwater would have to be weighed against the possible adverse effects. The principal location of flood control benefits would be in Valley City.

Without increasing the amount and frequency of drawdowns to provide the additional storage, the other method of revising the operating plan to increase flood control effectiveness is to modify the rates of flow released during the flood to maximize the downstream stage reductions. Several factors limit the degree to which modifications of this type can be made to the existing Baldhill Dam:

1. For floods with large volumes of flood runoff, the relatively small amounts of flood control storage limit the effectiveness of that storage in reducing downstream flood flows.

2. The dual-use nature of the water storage limits the effectiveness of that storage for flood control. Although maximizing flood damage reduction is a prime concern, an equal concern is assuring that the water level after spring runoff is at the full pool level. These two purposes can cause conflicts about how much water should be released.

3. For several past floods (the 1979 flood being the most recent), emergency levees were constructed during the flood to prevent damages at Valley City. Peak flows for the 1979 flood were delayed about 4 days through use of the existing operating release rate schedules for Baldhill Dam. Valley City needed all of this time to get its temporary levees in place to prevent flood damages. This delay of the peak flows, as well as keeping flows below damaging levels, is an important consideration for Valley City, thus giving them as much time as possible to prepare their lines of protection.

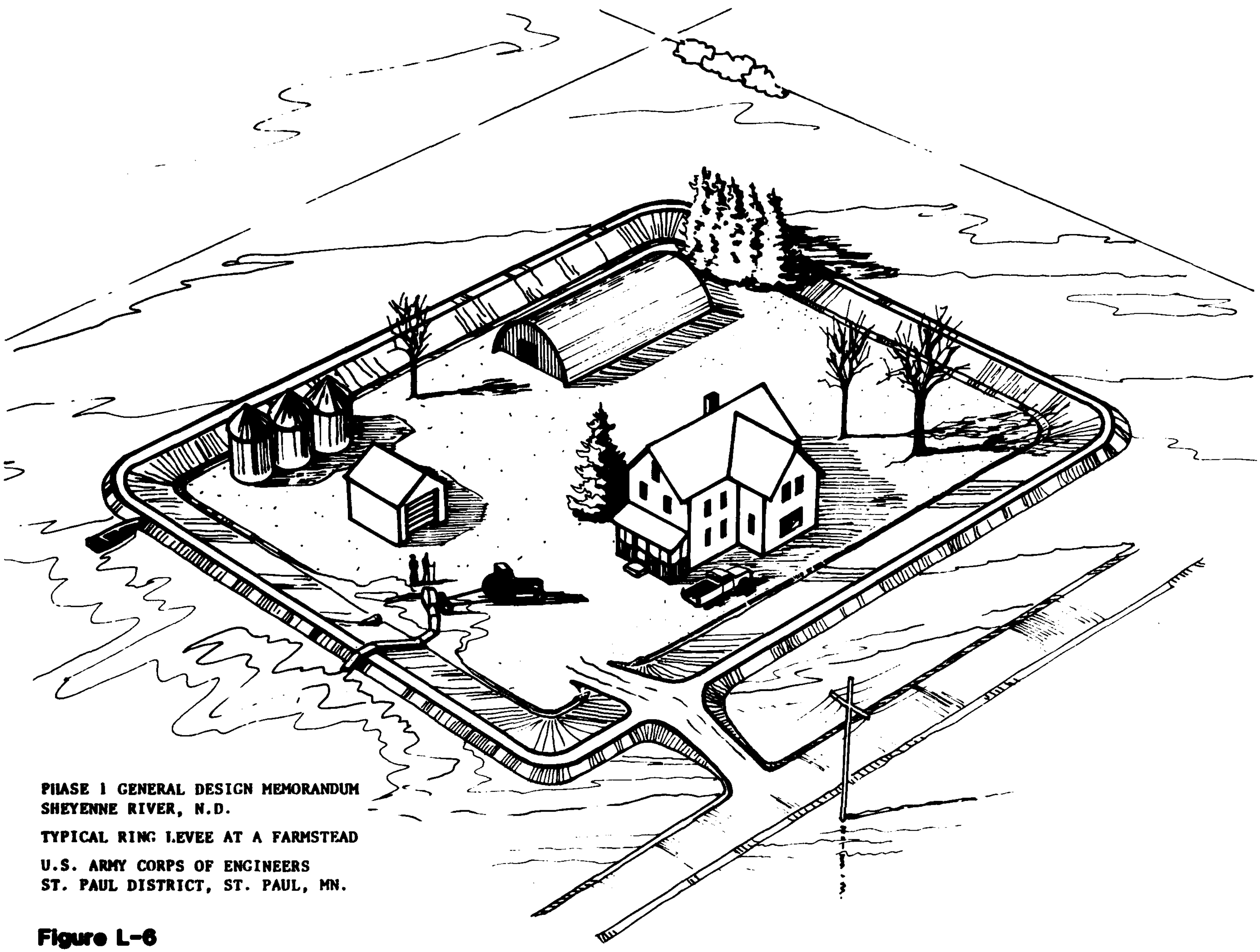
4. At the start of any given flood, the predictions of the runoff hydrograph are subject to significant error. During this same period the decisions on release rates from the Baldhill Dam must be made. About a week after a flood starts, the reliability of the predicted runoff hydrograph improves to a point where the adjustment of release rates can be made to try optimizing the flood stage reductions downstream. Most of the flood control storage has been used by this time, and the actual ability to optimize the discharges from the dam is very limited in scope.

5. Since the lake level must be drawn down before the flood to provide flood control storage, there is no assurance that any given amount of flood control storage will in fact be available for the flood.

Recognizing all these limitations, the existing operating plan appears to provide the optimum tradeoff for water supply and flood control operation.

Ring Levees at Farmsteads, Residences, and Small Developments

This alternative would consist of the construction of earthen levees around farmsteads or residences, protecting all buildings and equipment surrounded by the levees. This concept is shown in figure L-6.



PHASE I GENERAL DESIGN MEMORANDUM
SHEYENNE RIVER, N.D.

TYPICAL RING LEVEE AT A FARMSTEAD

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT, ST. PAUL, MN.

Figure L-6

Ring levees at farmsteads would be costly both in terms of the land needed for levee construction and the expense of the actual construction. Using the criteria of protection to the 1-percent chance flood height plus freeboard or a 5-foot minimum height levee, costs for a farmstead or residence along the Sheyenne River between Kindred and the mouth could range from $12,000 to $25,000. These figures are based on a levee having 2 on 1 side slopes, a 5-foot top width, interior drainage handled by a Crisafulli or Liteweight hydraulic submersible pump and a small ponding area, and all earthen materials needed for the levee coming from the construction area.

Using these criteria and estimating the number of farmsteads and residences in each reach, cost estimates were developed for the reaches from Kindred to the mouth of the Sheyenne River. First costs of ring levee protection for farmsteads and residences between Kindred and Horace would range from $1.0 to $4.3 million, with an average annual cost of $200,000. The Horace to West Fargo reach would involve a first cost of $1.3 to $5.2 million and an average annual cost of $250,000. From West Fargo to Harwood, the first cost would be $2.0 to $7.7 million with an average annual cost of $370,000. The Harwood to the mouth reach would involve a first cost of $0.6 to $2.8 million and an average annual cost of $130,000.

A detailed economic analysis has been completed to determine the economic feasibility of farmstead ring levees along the Red River of the North main stem. Costs and benefits were computed for each county and for the 5- ,10-, 20-, and 100-year floodplains. Three basic curves were computed, representing a low, mid, and high range of average annual costs of the levee per farmstead relating to various depths of flooding. Benefit-cost ratios for the 5- to 100-year floodplains range from 3.7 to 2.1, respectively, indicating the alternative has good economic feasibility. The preliminary ring levee designs for the Sheyenne River are similar to those in the Red River of the North study. Therefore, the benefit-cost ratio for the Sheyenne River alternative should be similar.

At the least, the benefits would exceed the costs. The Soil Conservation Service has established a cost-sharing program and eligibility criteria. A similar system would have to be adopted by the Corps of Engineers for the Corps to participate in the implementation of this program. This program could effectively supplement other flood damage reduction alternatives.

Enlarge Cass County Drains Nos. 13, 21, and 45

Enlargement of the existing Cass County Drains Nos. 13, 21, and 45, including maintenance of the drains and installation of control gates, would involve major work and expenditures on each drain and would provide greater capacity for both drainage and passage of flood flows. The drains are west of West Fargo, northeast of West Fargo, and in the area between Harwood and Argusville.

Enlarging Drain No. 21 would increase flood protection for West Fargo from overland flows from the Maple River and overland flows from the Sheyenne River that break out to the west in the Horace area. This enlargement would not noticeably affect flood stages along the Sheyenne River through West Fargo, although flood stages might be reduced somewhat at the north edge of West Fargo as a result of a slight reduction of the backwater influence of Drain No. 21.

Enlarging Drain No. 45 would reduce drainage problems in the east portion of West Fargo. It could reduce damages resulting from overbank flooding in the east section of West Fargo by providing an outlet for the overflow water. Enlarging Drain No. 45 would not significantly reduce flood stages through West Fargo.

Enlarging Drain No. 13 would ease flood stages in the agricultural area between Harwood and Argusville, but would probably have little

effect, if any, on flood stages in the immediate vicinity of the Sheyenne River near Harwood. Flood stages between I-29 and the Red River of the North are influenced principally by flood levels on the Red River of the North; consequently, enlarging Drain No. 13 would have little effect on this area.

Maintenance of the drains is a necessary element in their proper functioning; however, the most significant effects of improved drain maintenance would be recognized in the improved runoff characteristics for fairly frequent rainfall events. Improved maintenance would probably not result in major reductions of flood damages. However, proper maintenance would ensure that the full drain capacity would be available and the integrity of the drain could be retained.

Installation of control gates to retard floodwaters in these drains would probably worsen flood problems. These three drains normally run off before major flows from the upstream areas. Retarding these flows could add to the peak discharges and/or overflow conditions. These drains also function to handle overflows from the Sheyenne and Maple Rivers during major floods. Reducing their capacity to handle these overflows could increase flood levels. Enlarging Drain No. 21 could be combined with other measures to effectively reduce flood damages.

Install Retention Control Structures on Drains

Installing retention control structures on drains could have a wide range of effects on flood levels along the lower Sheyenne River. The effects would vary according to the location of the drain, timing and magnitude of flows from the specific flood, storage capacity of the drain, and type and operation of the control structures. The drains in the area downstream of Kindred appear to normally run off before peak

flood flows along the Sheyenne River. Allowing them to drain off without control structures would probably provide for the best reduction of flood peaks in the lower Sheyenne River basin. Retarding the flood flows from these drains could worsen flooding conditions.

The drains between Kindred and Baldhill Dam, if controlled, could reduce the magnitude of the first peak of a major flood. However, they would probably have little or no effect on the second and main peak of the flood and could possibly worsen the second peak if the drains were not properly controlled.

The drains between Baldhill Dam and Warwick, if controlled, could help reduce the main flood peak from above Baldhill Dam but would have no effect on the first flood peak coming from the area below Baldhill Dam. The magnitude of the effect on the flood peak would be a function of the storage capacity of the drains and the amount of drainage area controlled. The drains above the Warwick area have very little effect on the peak flows. Controls on these drains would not reduce peak discharges in the lower Sheyenne River basin.

A coordinated plan of control structures on drains, especially the major drains, could reduce flood stages in the lower Sheyenne River basin.

Modify Bridges and Highways

Bridge structures that are too small to effectively pass floodwaters can increase flood levels immediately upstream of the bridge. This effect is especially pronounced when ice and/or large trees catch in the confined bridge opening, causing further restrictions and even greater increases in flood levels upstream of the bridge.

The higher flood levels upstream from the bridge are normally localized and affect only the areas immediately upstream of the bridge. In some cases, however, the floodwaters can be rerouted into another drainage pattern. Enlarging certain bridge openings could reduce localized flood problems but would not result in major basinwide flood damage reductions.

Before highways and associated ditches were built, floodwaters followed natural drainage patterns. Highways were constructed across natural drainage patterns and culverts were placed through the highways or bridges were built to allow for drainage. These culverts and/or bridges are normally designed to pass reasonable flows; however, when major floods occur, the openings are not sufficient to pass the floodwaters without causing backup. This effect is most pronounced with the north-south roads from Kindred to West Fargo where the highways act as levees directing the flow until they are overtopped. Enlarging the openings could reduce some of the flooding effects in the lower basin, although the major influence would probably be in determining which way the floodwaters would be directed and which area would receive the floodwaters.

Snagging and Clearing the Sheyenne River

Snagging and clearing along the Sheyenne River would consist of removing fallen trees and other debris from the river channel to facilitate flows in the river. Clearing the debris before a flood would help reduce the number of trees that would catch on bridge openings and constrict flow through bridges. The most noticeable effects would be on the smaller, more frequent floods. For major floods, such as the 1950, 1969, 1975, 1979, and larger floods, snagging and clearing would do little to lower flood levels. The most pronounced effect would be at bridge openings. Removal of snags and clearing of fallen trees from the riverbank generally would have an adverse effect on the stream fishery, aesthetics, and wildlife in that reach of the river.

The Sheyenne River was cleared of snags and fallen trees in the lower reaches after the 1975 flood. Additional work was done after the 1979 flood. Major benefited areas would be along the reaches immediately adjacent to the snagging and clearing activities.

Wetland Restoration

Control structures would be placed on drainage ditches which have drained wetlands and earthen levees would be constructed to increase the storage capacity of existing wetlands in the watershed between Baldhill Dam and Kindred. These wetlands may have provided either temporary or permanent storage for runoff, depending on the existence of natural outlets, the storage capacity of the wetlands, and the size of the drainage areas upstream. The effects of restoration would be a function of the storage capacity, drainage area controlled, and location within the basin.

As indicated in table L-9, approximately 253 square miles of drainage area between Baldhill Dam and Kindred could be controlled. Potentially suitable tracts in the drainage area from Baldhill Dam to Kindred were selected from inspection of topographic maps and false color infrared aerial photography. Approximately 360 wetland tracts with an average tract size of 80 acres are in this area. Although the average size is 80 acres, the size of each tract could vary significantly, either smaller or larger depending on the specific situation at the site. The actual wetlands are smaller than the tract sizes. Furthermore, there would be about 17.4 miles of earthen embankments needed with an average height of approximately 5 feet.

Table L-9 - Wetlands

Item	Reach between Kindred and Baldhill Dam
Pertinent data	
Drainage area controlled (square miles)	253
Number of wetland tracts	360
Average size of tract (acres)	80
Average embankment height (feet)	5
Total length of embankment (miles)	17.4
Economics	
Costs	
First cost ($million)	15 to 18
Average annual costs ($1,000)	1,300
Benefits	
Flood control ($1,000)(1)	
West Fargo	--
Agricultural (Sheyenne River)	80
Other	180
Subtotal flood control ($1,000)	260
Environmental benefits	(2)
Total benefits ($1,000)	260(2)(3)
Benefit-cost ratio	0.2
Environmental effects	
Woodland	
Acres	(4)
Percent of total affected	(4)
Grassland	
Acres	(4)
Percent of total affected	(4)
Wetland	
Acres	(4)
Percent of total affected	(4)
Cropland	
Acres	(4)
Percent of total affected	(4)
Mitigation lands required	0
Miles of river affected	0
Rare species affected	(4)
Threatened and endangered species affected	None known
Areas of national importance affected	(4)
Wild and scenic river affected	Probably none
Additional land affected by infrequent flood events	--
Aesthetic qualities affected	Yes

Table L-9 - Wetlands (cont)

Item	Reach between Kindred and Baldhill Dam
Social effects	
Properties acquired	
Farmsteads and residences	0
Businesses	0
Public facilities	0
Properties benefited	
Farmsteads and residences	664
Businesses	15
Public facilities	8
Persons relocated	0
Persons benefited	2,500
Lands required (acres)(total)	28,900
Cropland	11,300
Other	17,600
Lands benefited (acres)	
Cropland	36,400
Urban	150
Other	-
Transportation - roads severed	0
Flood damage reduction effectiveness	
Reduces total flood damages (percent)	
Valley City	0
West Fargo(1)	-
Total Sheyenne River(1)	0
Reduces 1-percent chance flood level	
Valley City	0
West Fargo	(5)

(1) Flood control benefits are derived only from reductions of the first peak on the Sheyenne River, are generally most effective in the reach from Kindred to West Fargo, and cannot be considered as fully creditable if this alternative is considered only by itself.

(2) Environmental benefits will be obtainable from this alternative; however, they are not quantifiable at this time.

(3) Benefits would increase when environmental benefits are credited.

(4) This environmental information was not available at the time the summary sheet was compiled. However, the areas affected are predominantly wetlands and cropland.

(5) Would have no noticeable effect on the 1-percent chance flood level in West Fargo. However, this alternative may have effects on flood levels in West Fargo of a more frequent flood nature, such as the 10-percent chance flood.

The first cost of this alternative ranges from $15 to $18 million; the average annual cost is $1,300,000. About $260,000 in flood control benefits could be credited to reductions of the first peak on the Sheyenne River. Generally, this alternative would be most effective in reducing floods between Kindred and West Fargo; however,, benefits could be gained in the area north of West Fargo. These benefits cannot be considered fully creditable if this alternative is considered only by itself; however, it could be an important component of an overall plan.

The dominant types of habitat affected by this alternative would be existing wetlands and drained wetlands used for agriculture or pasture. The exact areas and sizes have not been determined. Table L-10 summarizes the impacts associated with wetland restoration.

Table L-10 - Summary of impacts associated with wetland restoration alternatives

Item	Impact
Habitat	
Woodland	Little woodland would be affected. Some plantings around the restored wetland would be incorporated into the alternative. Wooded areas would provide cover and habitat to the wetland, enhancing its value.
Cropland	Marginal agricultural lands would be preferred. Most drainage was for agricultural purposes; therefore, most of the affected land would be cropland.
Grassland	Low-lying grasslands (presently used mostly for grazing) would be converted to wetlands.
Wetland	Depending on the operation of the restored wetlands for flood control, wetlands may benefit. Increasing the storage capacity of existing wetlands and operating them for flood control may adversely affect wetland vegetation.
Fish	Generally, the wetlands would be of little fishery value. Wetlands located near the river may reduce nutrient inflow to the river, resulting in some fish and aquatic benefits.
Miscellaneous	
Rare plants and animals	Depending on locations, some rare plants and animals could be affected.
Water quality	Turbidity would increase during construction. The impoundments could be operated to encourage development of vegetation. The wetlands would act as a sediment and nutrient trap.
Aesthetics	Wetland restoration would encourage wildlife activity in the area, generally considered a positive effect.
Planning constraints	
E.O. 11988 (Floodplain)	This alternative would be located in the floodplains of small creeks and tributary drainages.

Table L-10 - Summary of impacts associated with wetland restoration alternatives (cont)

Item	Impact
E.O. 11990 (Wetlands)	Wetlands would be created or increased in size.
Preserve riverine environment	This alternative would not affect the riverine environment. Vegetation would be encouraged at wetland sites.
Federal threatened and endangered species	None known.
Federal and State wild and scenic rivers	Probably no effect. Wetlands would be located away from the Sheyenne River. Water quality may be improved.
<u>Areas of critical national importance</u>	
Game management areas, refuges, grasslands, etc.	None
Cultural resources	This alternative would have little impact on cultural resources in former wetlands created as a result of Pleistocene glaciation, unless these wetlands were restored above former natural levels. The creation of wetlands in areas where none previously existed may affect cultural resources.

The alternative would produce various sizes and types of wetlands. These wetlands would provide diverse habitat types for waterfowl and other wildlife and recreation and aesthetic values.

In spring and summer, some waterfowl nest in small wetlands. In midsummer, waterfowl broods begin congregating in somewhat deeper wetland environments because of the greater abundance of food, including insects and invertebrates preferred by the young. By September, the local nesting waterfowl gather in larger wetlands, referred to as concentration or staging areas, where plant and animal foods are plentiful.

The prairie provinces pothole region of the Dakotas and adjacent Canada as well as the northwest territories and Alaska constitute the principal nesting grounds for diving ducks such as the ring-necked ducks and the redhead. Waterfowl differ in their nesting requirements.

The mallard and blue-winged teal are meadow nesters. Preferred nesting habitat includes grassy meadows, adjacent hayfields, and shallow marsh environments. Wood ducks nest in the cavities of trees along rivers or oxbows. The wooded floodplain constitutes the prime breeding area for wood ducks. Coots prefer nesting habitat similar to that of diving ducks in that they commonly construct floating nests on rafted debris within deep-water cattail and bulrush marshes. Redheads nest atop muskrat houses or construct nests in vegetation along the shoreline.

Wetlands also benefit furbearers which have high recreation value in North Dakota. Many furbearers are also trapped and have high economic value. The restoration of wetlands would increase the furbearer population. Besides economic value, they have aesthetic, biological, and scientific research value. The species associated with wetlands

include muskrat, beaver, raccoon, and mink. The preferred food of muskrats is cattail, bulrush, and bluejoint grass, although many other types of vegetation are also eaten. Deep permanent wetlands such as Type 4 and Type 5 are preferred. Raccoons use all types of wetlands from inland fresh meadows to wooded swamps, including habitats usually occupied by muskrats. A favorite food of raccoons is crayfish which inhabit waterlogged soils.

The fishing values of wetlands would probably be low because of the shallow characteristics and drawdown. However, some areas could be operated to maintain a fishery or used as spawning grounds.

Wetlands have a number of nonconsumptive uses. In many cases, a monetary value cannot be placed on these uses, and in most cases they do not equate with other uses or monetary items such as flood control or agriculture. A unique value of wetlands is their diversity of aquatic and terrestrial life. Of the 164 animals associated with wetlands in North Dakota, 138 are birds (Barber et al., 1977). Wetlands provide valuable nesting functions as well as cover, food, and migratory resting areas for a diversity of shorebirds, passerines, and birds of prey.

Wetlands provide hunting, trapping, aesthetic, recreation, scientific, educational, and social benefits. Wetlands are also stabilizing forces on the physical environment because they sustain high water tables to balance precipitation deficits, retain excess surface water, and serve as settling basins for silt and chemicals to reduce pollution in downstream waters.

A strong correlation exists between the number of depressions holding water and waterfowl use particularly during breeding season. An interspersion of large wetland areas of adequate depth to ensure permanence throughout the summer among numerous small, temporary areas is the best waterfowl producing combination.

Waterfowl prefer the privacy of small wetland areas for courtship, using wetlands as small as a tenth of an acre which hold surface water for a few days or weeks in April or May. Later in the summer, after the broods have hatched, the hens and their broods congregate in large numbers on the larger bodies of water.

A variety of wetland types would be created by this alternative. The plan could also include tree, shrub, and grass plantings to improve wildlife and aesthetic values of the wetlands.

As a result of wetland construction, turbidity of receiving waters might increase temporarily but would probably improve over the long term because of the sedimentation and nutrient holding characteristics of the wetlands.

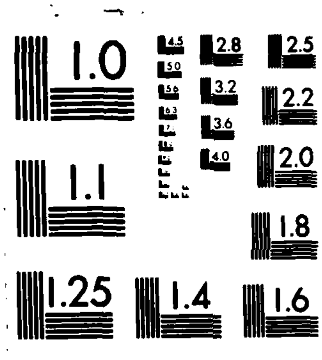
This alternative would not involve any acquisition of farmsteads, residences, businesses, or public facilities. It would benefit 664 farmsteads and residences, 15 businesses, and 8 public facilities. Within the same area, between Kindred and West Fargo, 2,500 persons would benefit from reduced flooding.

This alternative would not have a significant effect on the 1-percent chance flood level in West Fargo. However, it might affect flood levels in West Fargo for more frequent floods, such as the 10-percent chance flood.

Much of the farmland in this region was created or improved by wetland drainage. Programs at various levels of government, including local and regional drainage associations, have aided individual farmers to this end, supplementing their economic incentives. Nationally, these efforts had affected 100 million acres by 1960; by 1970, only 170 million acres remained as potentially drainable for agriculture.

AD-A146 716 GENERAL REEVALUATION AND ENVIRONMENTAL IMPACT STATEMENT FOR FLOOD CONTROL..(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT JAN 84 3/5

UNCLASSIFIED F/G 13/2 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Efforts to reverse this trend have arisen during times of agricultural surplus and in response to conservation needs - as drainage and "big-farm" technology have destroyed wildlife habitat. Preservation and restoration of wetlands are also being used as supplementary methods of flood control.

Components of the alternative considered include restoring previously drained wetland areas, increasing the temporary storage capacity of existing wetlands, plugging some drainage ditches for temporary storage, and constructing small temporary storage dams in presently dry ravines. These components would have varying flood control, biological, economic, and social consequences. The social effects can be categorized as political conflict, life-style changes, institutional changes, or community dislocation. Because the details of this alternative are not yet resolved, the following discussion of social impacts must be considered a tentative outline of some possible effects (see table L-11).

Table L-11 - Probability of social impacts for components of the wetland restoration alternatives

	Social impact areas			
Component	Political conflict	Community dislocation	Life-style changes	Institutional changes
Restoring drained wetland	High	Low	Moderate	High
Increasing temporary storage capacity of existing wetlands	High	Low	Low	High
Operating drainage ditches for flood control	Low	Low	Low	Moderate
Temporary storage dams	Moderate	Moderate	Low	Moderate

Restoring drained wetlands would probably generate political conflict. Conflict could occur between different levels of government (Federal, State, regional, county, township), different agencies (U.S. Fish and Wildlife Service, Corps of Engineers, drainage boards), or

different interest groups (farmers, hunters, conservationists). These conflicts would rest on differences in values, interests, and organizational goals.

This component would also probably cause institutional changes. Some agencies would lose legal authority or responsibility presently held; others would gain responsibility or take on new roles. Relations between organizations would be changed either legally or through the fact of their changed functions. Laws and regulations related to land use would probably be changed.

Less probable would be changes in the life styles of area residents. Land would be diverted from its present use (farming) to a former use (wildlife habitat), but entire farms would not necessarily be acquired. Hunting would become somewhat more available within the region, depending on the size of the restored tracts, their biological success, and management policies. Depending primarily on tract size, these restorations would probably cause little dislocation to community facilities, such as disruption of roads or utilities or relocation of farmsteads.

Increasing temporary storage capacity of existing wetlands has already generated some political conflict between Federal agencies because of the negative biological impacts. Its social effects in general would be similar to those of the restoration component, but it would be less likely to change the life styles of farmers or other users of the land.

Using existing drainage systems for additional storage would probably require some institutional changes similar to those discussed above as agencies' authorities and functions changed to operate the drains for an added purpose. However, the probability is low that the other factors would be significantly affected.

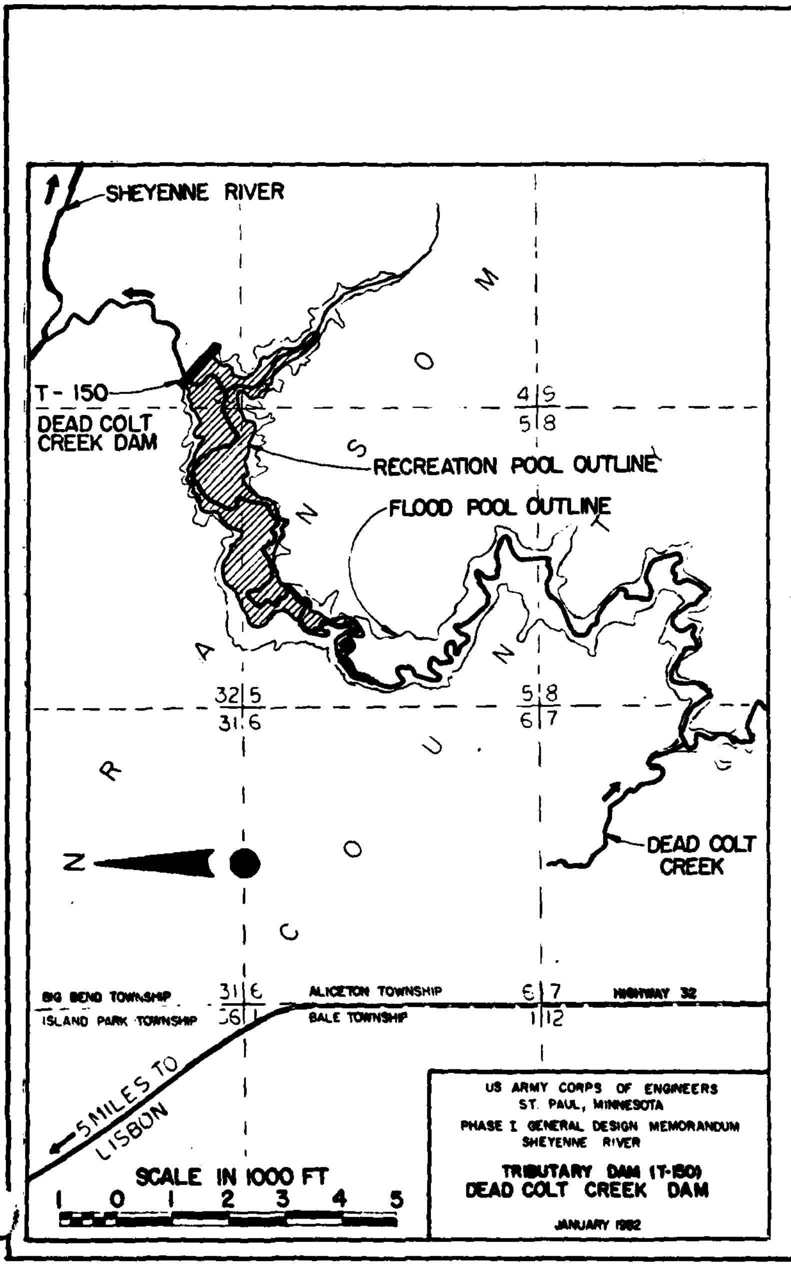
Small temporary storage dams would have a moderate probability of causing political conflict, depending primarily on the number, size, and location of the structures. They might also cause community dislocations because some roads or utilities would be inundated and farmsteads would possibly be acquired.

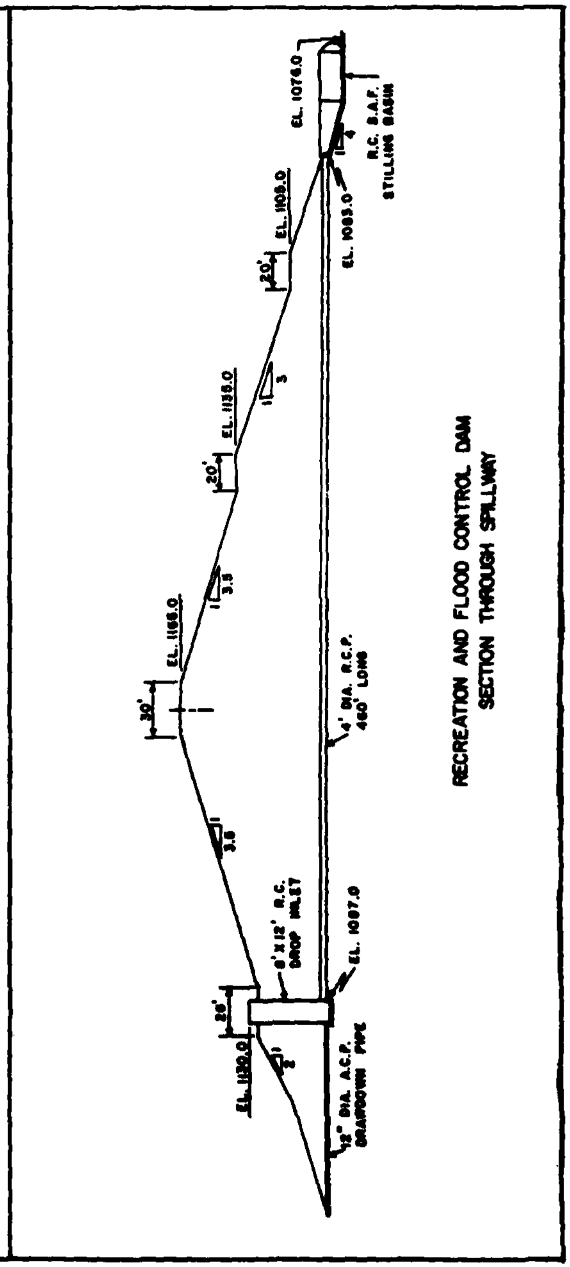
The responsibility of operating numerous small dams would cause some institutional changes. The residents' ways of life would be less likely to change because most of the pools would probably be on unusable or marginal farmland.

Approximately 11,300 acres of cropland and 17,600 acres of other types of land would be required for implementation. The land benefited by this alternative would be 36,400 acres of cropland and 150 acres of urban land.

Tributary Dam T-150 (Dead Colt Creek)

This alterantive would consist of the construction of an earth-fill dam. It would be on a tributary to the Sheyenne River at about river mile 150. The tributary, Dead Colt Creek, enters the Sheyenne River from the south about 5 miles southeast of Lisbon. The dam would be located in Section 33 of Big Bend Township. Figure L-3 shows the location of the dam and the drainage area controlled. The outline of the flood pool and other more site-specific information are shown on figure L-7.


SHEYENNE RIVER
T- 150
DEAD COLT CREEK DAM
RECREATION POOL OUTLINE
FLOOD POOL OUTLINE
RANSOM COUNTY
DEAD COLT CREEK
BIG BEND TOWNSHIP
ISLAND PARK TOWNSHIP
ALICETON TOWNSHIP
BALE TOWNSHIP
HIGHWAY 32
5 MILES TO LISBON
SCALE IN 1000 FT
1 0 1 2 3 4 5
US ARMY CORPS OF ENGINEERS
ST. PAUL, MINNESOTA
PHASE I GENERAL DESIGN MEMORANDUM
SHEYENNE RIVER
TRIBUTARY DAM (T-150)
DEAD COLT CREEK DAM
JANUARY 1982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R.C. S.A.F. STILLING BASIN
EL. 1083.0
EL. 1105.0
EL. 1135.0
EL. 1166.0
4' DIA. R.C.P. 460' LONG
8'x12' R.C. DROP INLET
EL. 1087.0
EL. 1130.0
12" DIA. A.C.P. DRAWDOWN PIPE
RECREATION AND FLOOD CONTROL DAM
SECTION THROUGH SPILLWAY

FIGURE L-7

As shown in table L-12, the dam would control a drainage area of about 60 square miles. The total storage capacity of the 80-foot high dam would be 7,800 acre-feet. A 2,230-acre-foot conservation pool is being considered with this design. Therefore, the flood control storage capacity would be about 5,570 acre-feet. The surface area of the reservoir would be about 125 acres at the permanent pool level and 285 acres at the design flood pool level, resulting in about 160 acres being subjected to varying degrees of temporary inundation.

The first cost of this alternative would be about $1.7 million (at January 1982 price levels) with an average annual cost of $140,000. Flood control benefits would be derived only fiom reductions of the first peak on the Sheyenne River and would be most effective generally in the reach from Kindred to just south of West Fargo. Some reductions in the West Fargo area and north of West Fargo could occur, especially for the more frequent floods. The flood control storage in the Dead Colt Creek dam by itself would not significantly reduce flood damages in the basin. However, the dam could play a significant role as part of an overall plan. The flood control benefit estimates in table L-12 are quantified only for the reach from Kindred to West Fargo. Benefits may accrue in other reaches, but are not quantified. Recreation benefits accrue to the permanent pool and recreational facilities developed at the Dead Colt Creek dam. Although recreational benefits based on projected use data would be more precise, based on the average annual cost of a single-purpose recreation lake, average annual recreation benefits of about $100,000 are estimated. The benefit-cost ratio would be 1.8 indicating an economically feasible project.

Table L-12 - Pertinent information for Dead Colt Creek tributary dam

Item	T-150 Dead Colt Creek
Pertinent data	
Drainage area (square miles)	60
Storage capacity (acre-feet)	
Flood control	5,570
Conservation pool	2,230
Total storage (acre-feet)	7,800
Area flooded (acres)	
Flood pool	285
Conservation pool	125
Dam	
Type	Earth fill
Elevation, top of dam (feet msl)	1165
Height (feet)	80
Economics	
Costs	
First cost ($million)	1.7
Average annual cost ($1,000)	140
Benefits	
Flood control ($1,000)	
West Fargo	-(1)
Valley City	0
Agricultural (Sheyenne River)	50(1)
Other	110(1)
Subtotal flood control ($1,000)	160(1)
Recreation	100(2)
Total benefits ($1,000)	260(1)
Benefit-cost ratio	1.8
Environmental effects	
Woodland (acres)	30
Grassland (acres)	225
Wetland (acres)	Little
Cropland (acres)	30
Miles of river affected	5
Rare species affected	No
Threatened and endangered species affected	None known
Areas of national importance affected	No
Wild and scenic river affected	Probably none
Additional lands affected by infrequent flood events	-
Aesthetic qualities affected	Yes

Table L-12 - Pertinent information for Dead Colt Creek tributary dam (cont)

Item	T-150 Dead Colt Creek
Social Effects	
Property acquired	
Farmsteads and residences	0
Businesses	0
Public facilities	0
Properties benefited (3)	
Farmsteads and residences (3)	503
Businesses (3)	12
Public facilities (3)	6
Persons relocated	0
Persons benefited (3)	1,500
Lands required (acres)	
Cropland	320
Other	460
Lands benefited (acres) (3)	
Cropland	23,400
Urban	100
Other	-
Transportation - roads severed	1
Flood damage reduction effectiveness	
Reduces total flood damages (percent)	
Valley City	0
West Fargo	Some (3)
Total Sheyenne River	Some (3)
Reduces 1-percent chance flood level	
Valley City	0
West Fargo	(4)

(1) Flood control benefits would be derived only from reductions of the first peak on the Sheyenne River and would be generally most effective in the reach from Kindred to West Fargo. This dam must be coupled with other alternatives that would reduce the second peak before it can be considered effective. Benefits are only estimated in the reach from Kindred to West Fargo and cannot be considered as fully creditable if this dam is considered by itself.

(2) Based on estimated average annual cost of a single-purpose project for recreation only which would be constructed to a smaller size than proposed project.

(3) Benefited along the Sheyenne River from near Anselm to just south of West Fargo.

(4) Would have no noticeable effect on the 1-percent chance flood level in West Fargo. However, it may have effects on more frequent flood levels in West Fargo, such as the 10-percent chance flood.

The dominant habitat that would be affected is grazed grassland. The duration of storage for the larger floods may be long enough to kill the grassland vegetation. Regrowth would consist mostly of weedy species such as thistle and dock. Because of the better water quality of Dead Colt Creek and more year-round flow, this site would provide fish habitat. The flood pool would lower fishery values by removing the existing habitat and sources of future habitat. A summary of environmental impacts is presented in table L-13.

Table L-13 - Summary of impacts associated with Dead Colt Creek tributary dam

Item	T-150 - Dead Colt Creek dam
Habitat	
Woodland	30 acres affected. Extensive and valuable woodlands of the lower basin are nearby.
Cropland	30 acres affected.
Grassland	225 acres affected.
Wetland	Little effect.
Fishery	Fishery would be adversely affected by temporary inundation of flood pool. Turbidity, erosion, and dead vegetation would be adverse to fishery.
Miscellaneous	
Rare plants and animals	None known.
Water quality	Temporary increase in turbidity caused by construction. Water storage and shoreline erosion could increase downstream turbidity and sedimentation.
Aesthetics	The weedy vegetation resulting from temporary inundation would be in contrast to existing prairie grasslands. Weedy vegetation would provide less desirable wildlife habitat and therefore affect wildlife populations. A temporary negative impact would result from construction activities.
Planning constraints	
E.O. 11988 (Floodplain)	The project would be located in the floodplain.
E.O. 11990 (Wetlands)	Little wetland would be affected.
Preserve riverine environment	Some woodland and the creek floodplain would be lost.
Federal threatened and endangered species	None known.
Federal and State wild and scenic rivers	Probably not significant. The impacts to water quality as a result of construction and operation of the dams could influence designation potential.

Table L-13 - Summary of impacts associated with Dead Colt Creek tributary dam (cont)

Item	T-150 - Dead Colt Creek dam
Areas of critical national importance	
Game management areas, refuges, grasslands, etc.	None.
Cultural resources	Two known prehistoric sites may be affected by the dam structure. Two prehistoric site leads are within the T-150 drainage subbasin.

Mitigation of wildlife habitat losses caused by permanent and/or temporary inundation would be determined by the implementing agencies in consultation with the North Dakota Game and Fish Department.

Water quality impacts would center primarily on turbidity. Turbidity would increase during construction as a result of equipment movement and placement of fill. Some of the turbidity might be noticed on the Sheyenne River. Water storage in the flood pool would result in denuded shorelines and increased erosion. Turbidity and sedimentation would increase downstream.

The dam would have minimal adverse impacts on potential wild and scenic river designation. Water quality could have some impact. However, overall impacts are not expected to be significant.

No farmsteads and residences, businesses, or public facilities would be acquired. The Dead Colt Creek Dam would benefit about 503 farmsteads and residences, 12 businesses, and 6 public facilities downstream of the dam to just south of West Fargo. Within the same area, about 1,500 persons would benefit.

Construction of the dam would temporarily increase noise levels. However, because of the rural character of the area and the distance from people who might be affected, the increase is not expected to have a significant impact on any individuals or groups.

The alternatives would have no aesthetic impacts on the Sheyenne River or streambed. The groundwater levels in adjacent areas might be increased by the permanent storage pool; this increase could change vegetative patterns in those areas. Other aesthetic impacts could result from flood pool fluctuations. After the flood pool receded, the area that was inundated would be unsightly until it was vegetated again.

Approximately 320 acres of cropland and 460 acres of other types of land would be required for construction of this alternative. All of these lands include fish and wildlife mitigation lands. The lands benefited would include about 23,400 acres of cropland and 100 acres of urban land. Some reduction in flood damages from near Anselm to the mouth of the Sheyenne River is expected for the first peak on the Sheyenne River. However, no reduction can be attributed to this alternative alone because it must be coupled with other alternatives that would reduce the second peak.

The project described here is being considered for implementation by the North Dakota State Water Commission in conjunction with other non-Federal agencies and interests. Consequently, the project features and cost estimates are based on information provided by the North Dakota State Water Commission.

ALTERNATIVES THAT COULD BE MAJOR COMPONENTS OF FLOOD DAMAGE REDUCTION PLANS

The alternatives discussed in this section are those determined in stage 3 to have the potential to significantly reduce flood damages in the Sheyenne River basin and could be used as the major components of any comprehensive flood damage reduction plan. These major components are:

- Levees and flood diversion system around West Fargo/Riverside (M-29 to M-24).

- Diversion of the Sheyenne River (M-42 to M-24).

- Baldhill Dam.

Levees and Flood Diversion System Around West Fargo and Riverside (M-29 to M-24)

This alternative would consist of a flood diversion channel and levee to protect West Fargo and Riverside. The diversion channel would start about Sheyenne River mile 29, which is just north (downstream) of Interstate Highway 94, and then pass to the west of West Fargo generally along the alignment of Cass County Drain No. 21, rejoining the Sheyenne River just north of the city at about Sheyenne River mile 24. The earthen levees would be offset from both of the diversion channel edges approximately 125 feet and would follow the same general alignment, tying back into high ground on both the north and south sides of West Fargo/Riverside. Sheyenne River flood flows would be completely diverted, with two closure structures preventing flows from entering into the city: one at the downstream levee-river crossing to prevent backup flow into the city and one upstream near the Interstate Highway 94 bridge to divert the main flow of the Sheyenne into the diversion channel. The alignment and features are illustrated in figures L-8 through L-11.

The levees and flood diversion channel would be designed to protect the West Fargo/Riverside area from the standard project flood. More specific data for both the 1-percent chance and standard project flood designs are displayed in table L-14.

The levee segments identified on figures L-8 through L-11 as levee reaches A, B, C, D, and E would be designed to provide positive degrees of flood protection to the areas within the levees. The levee reaches F, G, and H, however, would be designed as levees with a low frequency level of protection. These would be overtopped by the larger floods, such as the standard project flood. Overtopping of these three segments of levee would ensure that protection would be provided by the remaining segments of levee to the urbanized portions of the community.

Table L-14 - Pertinent information: levees and diversion channel around West Fargo and Riverside (M-29 to M-24)

Item	100-year (1-percent chance) flood	Standard project flood
Pertinent data		
Design discharge (cfs)	3,400	(1)
Channel		
Bottom width (feet)	55	55
Top width (feet)	127	127
Length (miles)	4.0	4.0
Average depth (feet)	12 or less	12 or less
Levee		
Top width (feet)	10	10
Length (miles)	13.1	13.1
Average height with freeboard (feet)	6.0	6.5
Levee offset from channel (feet)	125	125
Economics		
Costs		
First cost ($million)	16.5	17.2
Average annual cost ($1,000)	1,450	1,529
Benefits		
Flood control ($1,000):		
West Fargo	18,870	19,551
Valley City	0	
Agricultural (Sheyenne River)	41	41
Other	3	3
Subtotal, flood control	18,914	19,595
Total benefits ($1,000)	18,914	19,595
Benefit-cost ratio	13	13
Net benefits ($1,000)	17,464	18,066
Social effects		
Property acquired		
Farmsteads and residences	1 (3)	1 (3)
Businesses	2	2
Public facilities	1	1
Properties benefited		
Farmsteads and residences	1,640	1,640
Businesses	150	150
Public facilities	40	40

Table L-14 - Pertinent information: levees and diversion channel around West Fargo and Riverside (M-29 to M-24)

Item	100-year (1-percent chance) flood	Standard project flood
Persons relocated	0	0
Persons benefited[2]	8,400	8,400
Lands required (acres)		
Cropland	65	70
Other	264	309
Lands benefited (acres)		
Cropland	--	--
Urban	1,700[4]	1,700[4]
Other	1,800[4]	1,800[4]
Transportation - roads severed	0	0
<u>Flood damage reduction effectiveness</u>		
Reduces total flood damages (percent)		
Valley City	0	0
West Fargo	95	98
Total Sheyenne River	65	68
Reduces 1-percent chance flood level		
Valley City	0	0
West Fargo	(5)	(5)

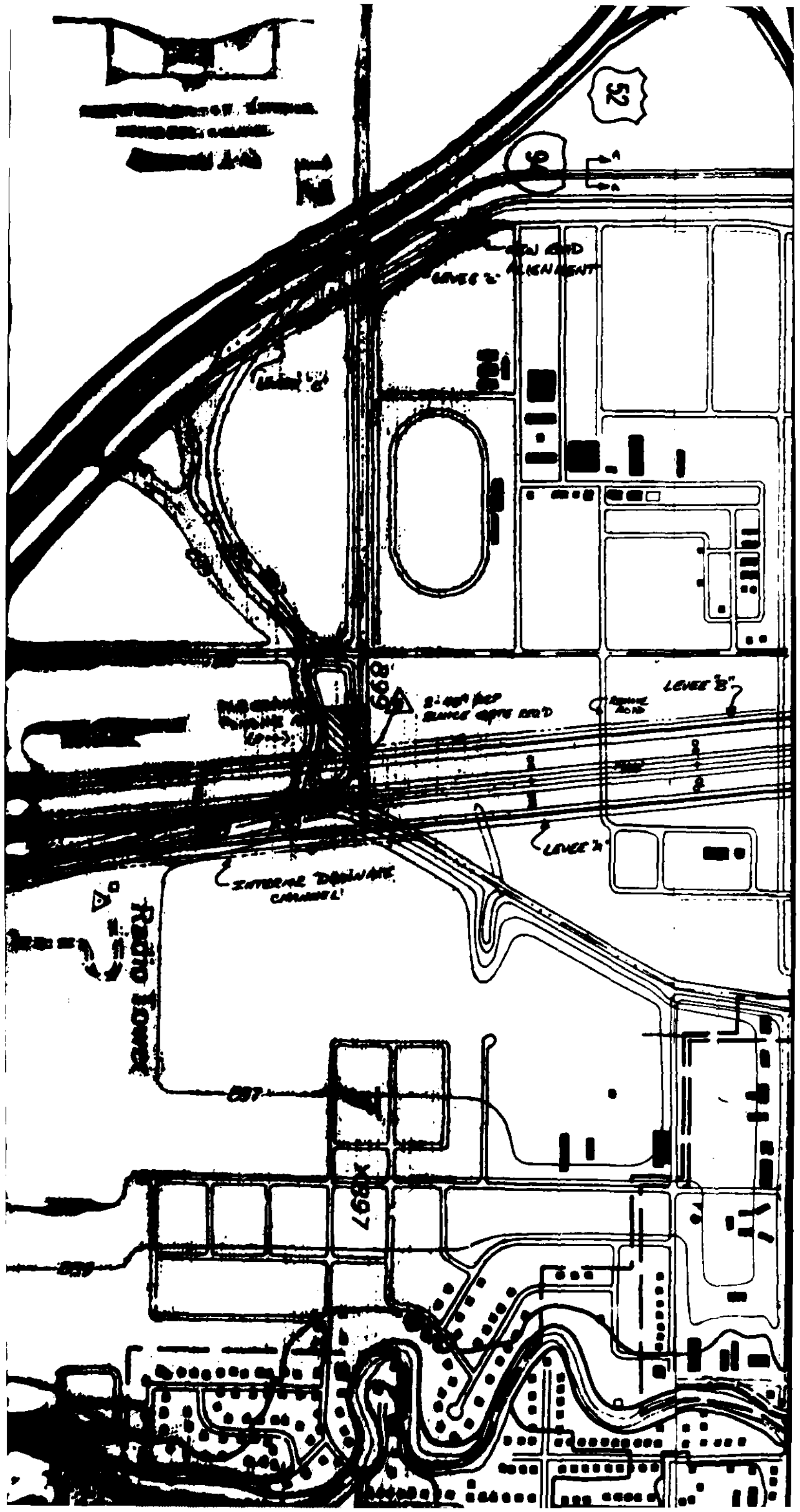
(1) *The design of the channel is the same as for the 1-percent chance* flood channel; however, because of the increased levee height and the larger magnitude of the flood, higher flows will be conveyed through the channel.

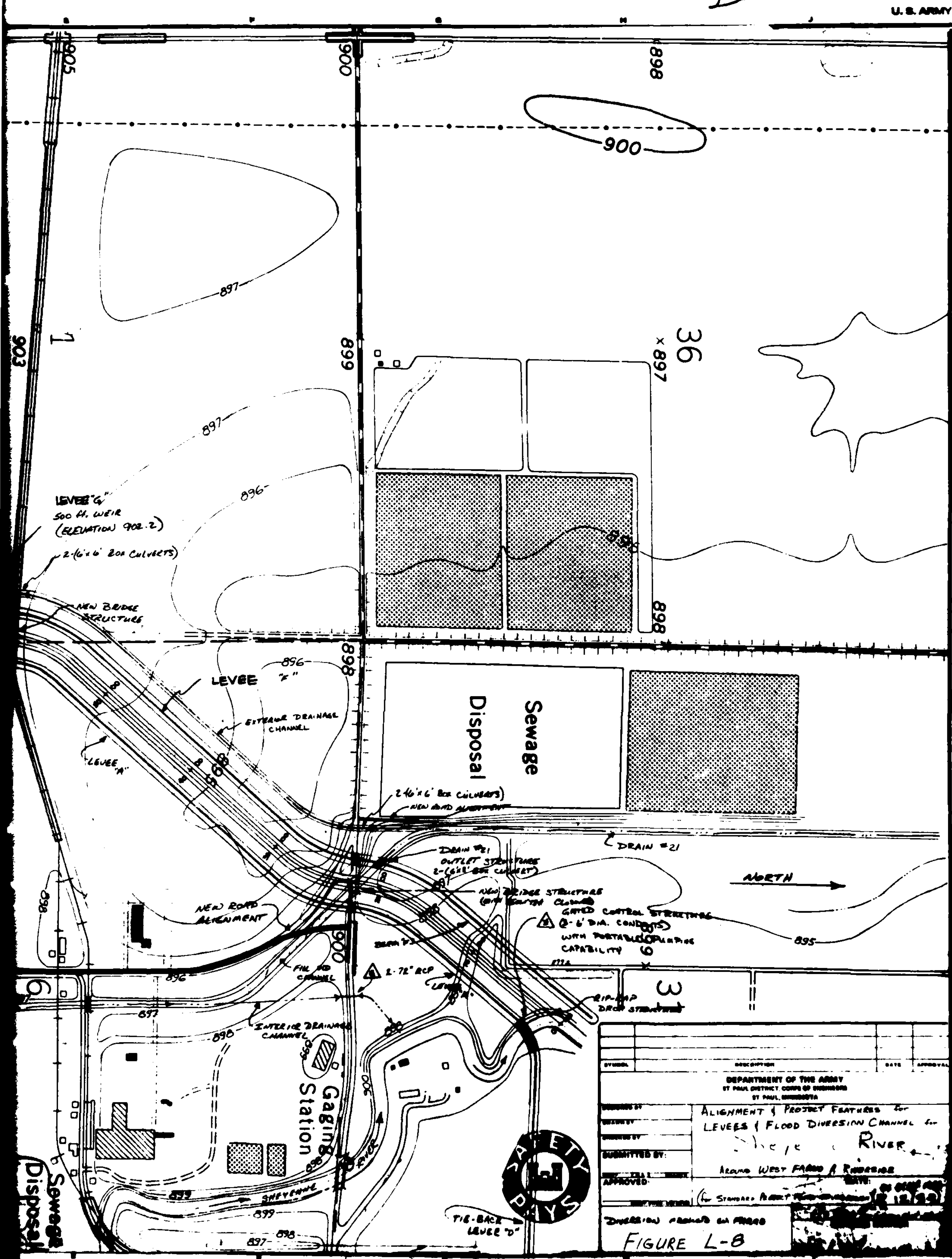
(2) Benefited by reduced flood damages.

(3) One multifamily complex.

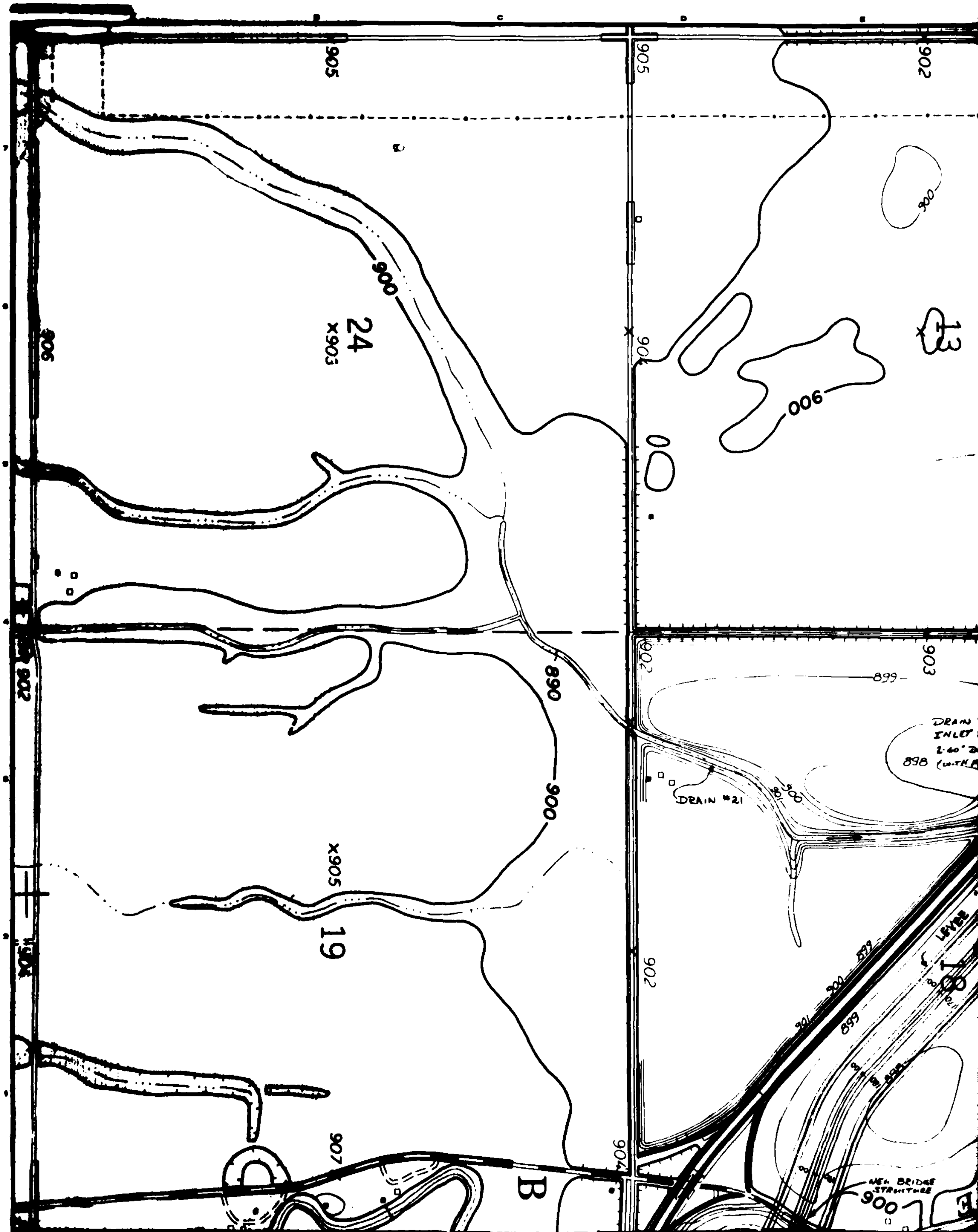
(4) Lands within leveed area currently used as cropland or vacant; most probably will be developed for urban use.

(5) Flood heights within the channel will be at or near natural flood heights without the project; however, those areas protected by the alternative will have greatly reduced flood levels and would be removed from the classification of floodplain.


52
94
899
LEVEE "B"
LEVEE "A"
INTERNAL DRAINAGE CHANNEL
Radio Tower
897

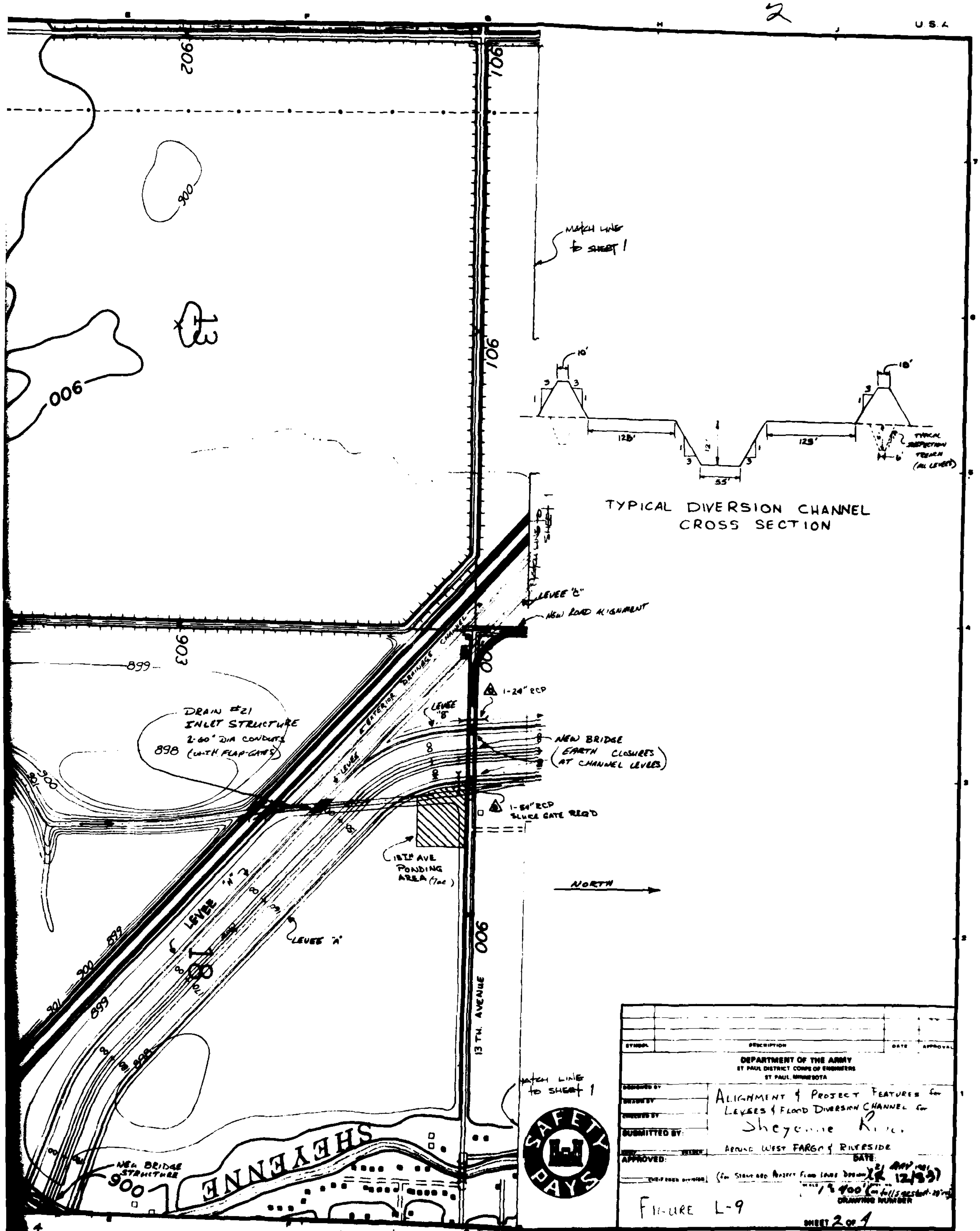

U.S. ARMY
900
898
897
896
895
36
3
Sewage Disposal
Gaging Station
LEVEE "G"
500 ft. WEIR
(ELEVATION 902.2)
2-(6'x6' BOX CULVERTS)
NEW BRIDGE STRUCTURE
LEVEE "F"
EXTERIOR DRAINAGE CHANNEL
LEVEE "A"
NEW ROAD ALIGNMENT
DRAIN #21
NORTH
INTERIOR DRAINAGE CHANNEL
SHEYENNE RIVER
TIE-BACK LEVEE "D"
RIP-RAP DROP STRUCTURE
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA
ALIGNMENT & PROJECT FEATURES for
LEVEES & FLOOD DIVERSION CHANNEL for
River
AROUND WEST FARGO & RIVERSIDE
FIGURE L-8
SAFETY PAYS

1

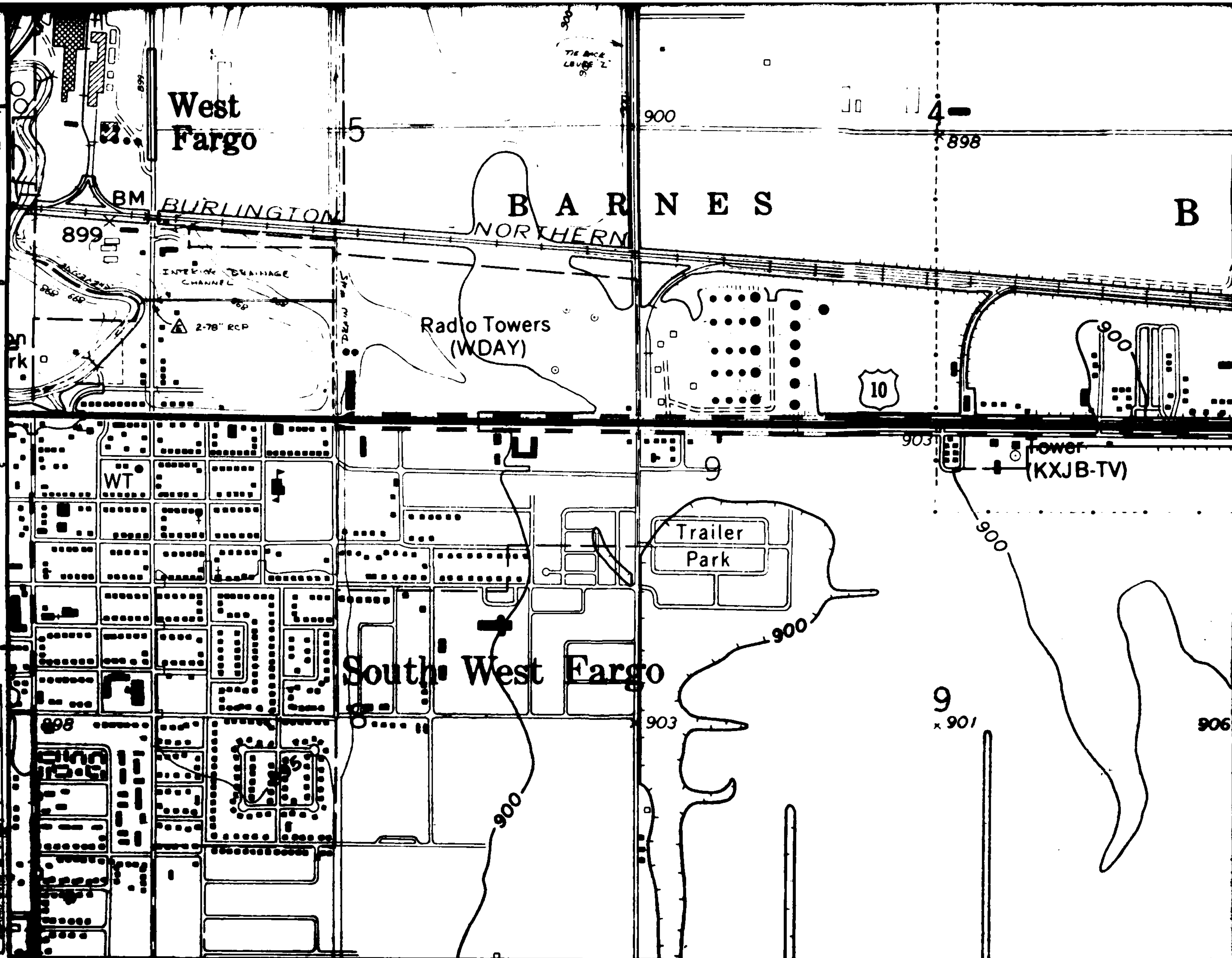


MATCH LINE to sheet 4

MATCH LINE to sheet 4

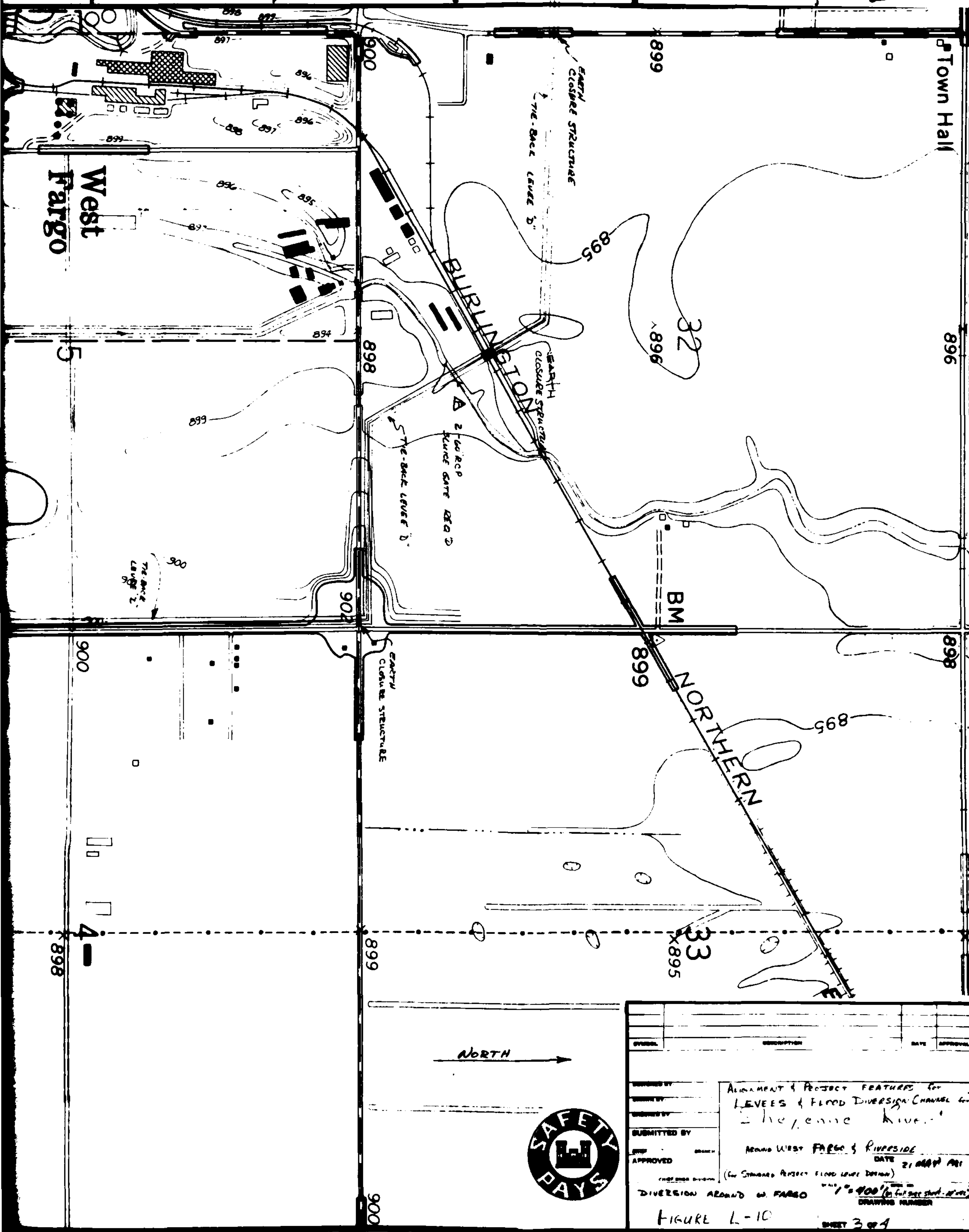


MATCH LINE TO SHEET 1
TYPICAL DIVERSION CHANNEL CROSS SECTION
LEVEE "C"
NEW ROAD ALIGNMENT
1-24" RCP
LEVEE "B"
DRAIN #21 INLET STRUCTURE 2-60" DIA CONDUITS (WITH FLAP-GATES)
NEW BRIDGE
EARTH CLOSURES AT CHANNEL LEVEES
1-54" RCP SLUICE GATE REQ'D
13TH AVE PONDING AREA
NORTH
LEVEE "A"
13 TH. AVENUE
MATCH LINE TO SHEET 1
NEW BRIDGE STRUCTURE
SHEYENNE
SAFETY PAYS
DEPARTMENT OF THE ARMY
ST PAUL DISTRICT CORPS OF ENGINEERS
ST PAUL, MINNESOTA
SUBMITTED BY:
APPROVED:
ALIGNMENT & PROJECT FEATURES FOR LEVEES & FLOOD DIVERSION CHANNEL FOR Sheyenne River
AROUND WEST FARGO & RIVERSIDE
DATE:
12/83
DRAWING NUMBER
FIGURE L-9
SHEET 2 OF 4



West
Fargo
BM
899
BURLINGTON
NORTHERN
BARNES
B
5
4
900
898
INTERIOR DRAINAGE CHANNEL
2-78" RCP
DRAIN #45
Radio Towers
(WDAY)
10
WT
9
903
Tower
(KXJB-TV)
Trailer
Park
South West Fargo
900
903
9
× 901
906
898

2



Alignment & Project Features for Levees & Flood Diversion Channel for Sheyenne River

Around West Fargo & Riverside

(for Standard Project Flood Levee Design)

DATE 21 MAY 1981

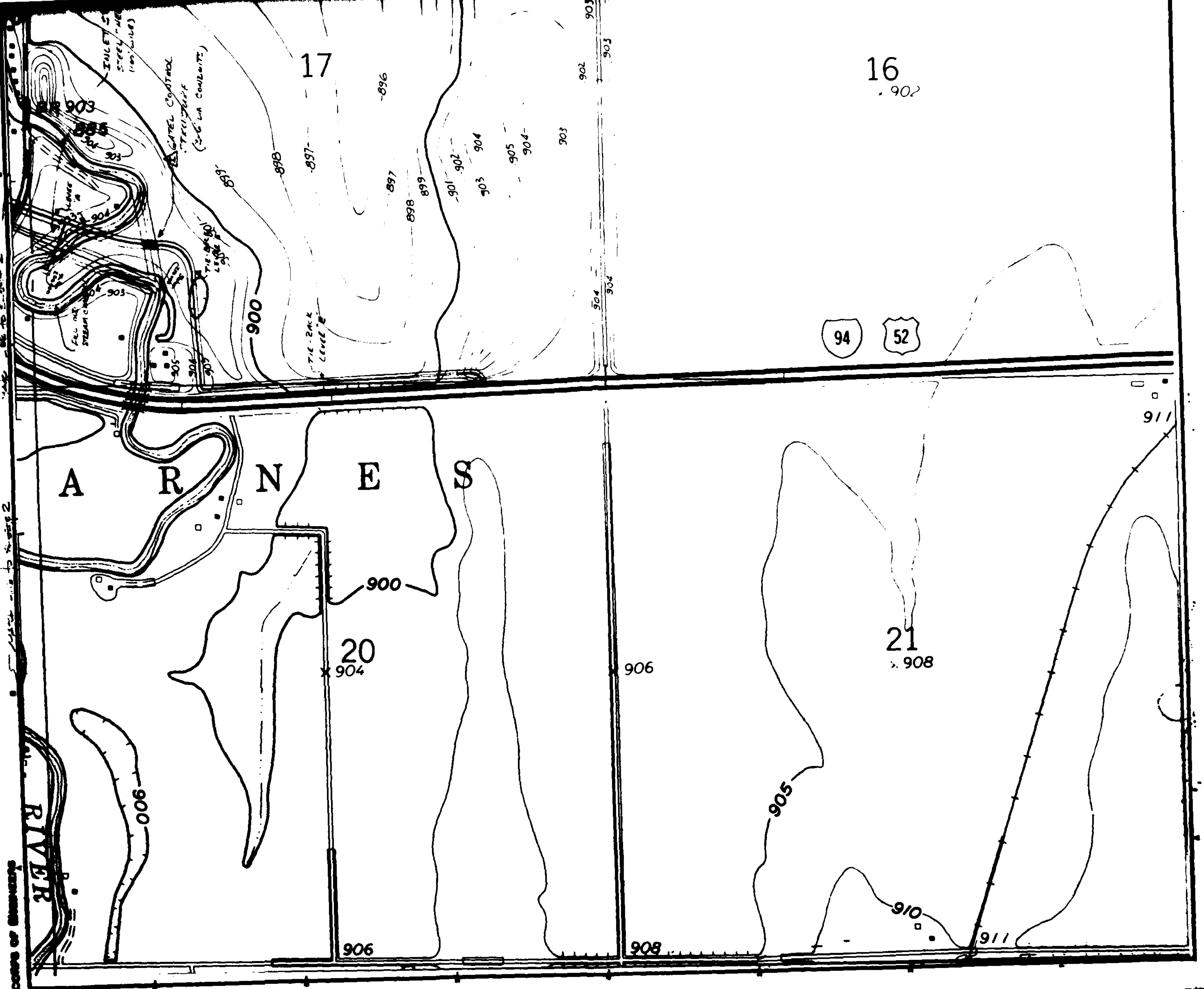
DIVERSION AROUND W. FARGO

SCALE 1" = 400' (on full size sheet)

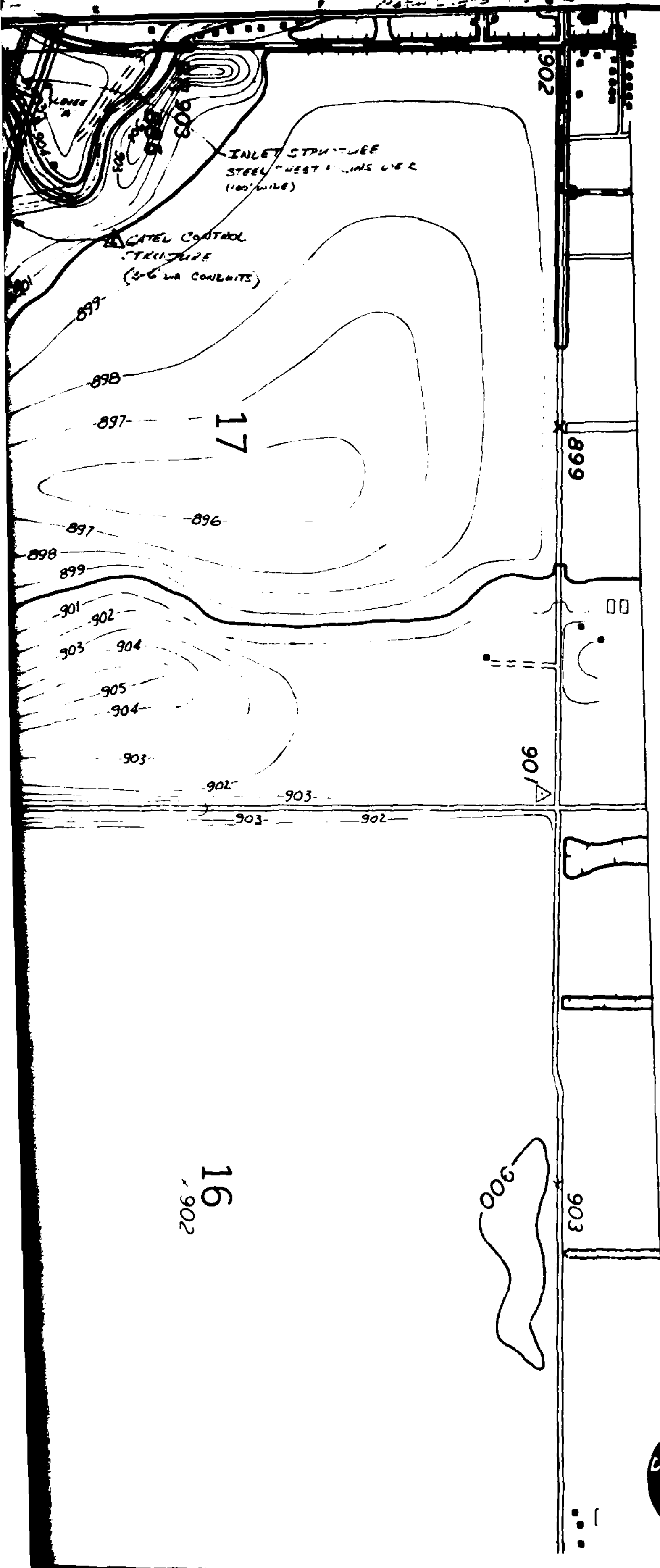
DRAWING NUMBER

FIGURE L-10

SHEET 3 of 4



A R N E S
RIVER
17
16
20
21
x 904
906
x 908
906
908
900
900
900
905
910
911
911
903
896
897
898
899
901
902
903
904
905
904
94
52
GATE CONTROL STRUCTURE
TIE-BACK LEVEE "E"



LEVEE ELEVATION TABLE
FOR SPF

LEVEE / REACH / LOCATION	STATION	ELEVATION (MSL)
REACH "A"		
DS OF OUTLET STRUCTURE	0+00	904.4
AT CASS COUNTY ROAD #10	35+40	905.1
AT RR BRIDGE	60+00	905.7
AT MAIN AVE (HWY 10)	84+00	906.0
AT 13TH AVE SOUTH	136+40	906.3
DS WEIR STRUCTURE	199+60	906.8
US WEIR STRUCTURE	199+60	909.1
REACH "B"		
DS END (CONT. US OF RR)	65+00	905.8
AT MAIN AVE. (HWY 10)	84+00	906.0
AT 13TH AVE SOUTH	136+40	906.3
US END	150+00	906.4
REACH "C"		
DS END	65+00	906.6
US END	150+00	906.6
TIE-BACK LEVEE "D"	—	904.4
TIE-BACK LEVEE "E"	—	909.1
REACH "F"		
DS END	0+00	901.3
US END	60+00	902.2
REACH "G"	—	902.2
REACH "H"		
DS END	150+00	908.6
US END	199+60	908.8

NOTE: THE DOWNSTREAM (DS) AND UPSTREAM (US) ENDS OF LEVEE "E" AND "C" ARE COINCIDENT

SYMBOL	DESCRIPTION	DATE	APPROVAL

U. S. ARMY ENGINEER DISTRICT, ST. PAUL
CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

DESIGNED BY:
DRAWN BY:
CHECKED BY:
SUBMITTED BY:
APPROVED:

Alignment & Project Features for Levees & Flood Diversion Channel for
Sheyenne River
Around West Fargo & Riverside

DATE: 21 MAY 1981

SCALE: 1" = 900'

DRAWING NUMBER

FI URT L-11

SHEET 4 OF 4

The diversion channel would be about 4 miles long, with a bottom width of 55 feet and an average depth of approximately 12 feet. About 13 miles of earthen levee is proposed, with a top width of 10 feet and an average height for the 100-year flood and standard project flood of 6.0 feet and 6.5 feet, respectively. These average heights include 3 feet of freeboard (a factor of safety).

First costs range from $16.5 million for the 1-percent chance to $17.2 million for the standard project flood level of protection. The average annual costs are $1.4 million for the 1-percent chance and $1.5 million for the standard project flood plan. No flood control benefits would be gained in areas upstream of this alternative. However, $18.87 million to $19.55 million in flood control benefits can be credited in the West Fargo area for the 1-percent chance and standard project flood designs, respectively.

This alternative would affect a variety of woodland, grassland, wetland, and cropland areas. Summaries of the impacts associated with the levee and diversion alternative can be found in table L-15. The areas generally have relatively low wildlife value because of the large proportion of cropland and adjacent urban areas. The diversion would follow an existing county ditch which contains both grassland and wetland habitats. Mitigation could probably be accomplished on project lands if similar habitat could be created.

Table L-15 - Summary of impacts associated with levees and flood diversion channel around West Fargo and Riverside (M-29 to M-24)

Item	Impact
Habitat	
Woodland	About 2 acres. Woodland affected where diversion leaves and reenters river. Limited value because of urban setting. Some use by squirrels and other small wildlife and birds.
Cropland	About 10 acres affected by diversion. About 60 acres affected by levees. Low wildlife value because of abundance in area.
Grassland	About 50 acres affected on slopes of existing diversion. Some use by urban wildlife.
Wetland	About 20 acres of seasonal wetland on the ditch bottom affected. Low value because of lack of interspersion and urban setting.
Fish	No impact.
Miscellaneous	
Rare plants and animals	No effect.
Water quality	Temporary increase in turbidity during construction.
Aesthetics	The levees would block existing views in residential area. Minimal impact.
Planning constraints	
E.O. 11988 (Floodplains)	This alternative is constructed in the floodplain and could change land use and nature of future developments.
E.O. 11990 (Wetlands)	Minor. Some wetland habitat is in existing ditch bottom.
Preserve riverine environment	Very minimal effect on riverine environment.
Federal threatened and endangered species	None known.
Federal and State wild and scenic rivers	No effect.

Table L-15 - Summary of impacts associated with levees and flood diversion channel around West Fargo and Riverside (M-29 to M-24)(cont)

Item	Impact
Areas of critical national importance	
Game management areas, refuges, grasslands, etc.	No effect.
Cultural resources	This alternative would not affect any known cultural resources; however, undetected cultural resources could be affected.

The diversion would temporarily increase turbidity and sedimentation during construction. These increases would have minor impacts on fish and wildlife. Both the 1-percent chance and standard project flood designs would have similar impacts, although the standard project flood design would have slightly higher total land requirements. Depending on location, additional woodland and cropland would be affected.

Aesthetic qualities would be affected both positively and negatively by either design. Vegetation can be considered a positive asset in any setting in which it does not form the characteristic landscape. A significant change in grade brought about by the construction of levees will block existing views to open space and river habitat in the residential area. Opportunities for the development of a nature trail or promenade along the river could mitigate the disruption of views. Plantings incorporated on the levee contour could be considered to have a positive effect on the visual landscape. Use of the existing channel drain alignment for the diversion channel would minimize disturbance to existing vegetation. The class B landscape character in this area is of common scenic value.

Both designs would involve the acquisition of one multifamily complex and two businesses--one business near the intersection of U.S. Highway 10 and the fairgrounds road and the second business at the south end of the fairgrounds road at 13th Avenue West. Both designs would also involve the acquisition of one public facility--the campgrounds just to the east of the fairgrounds. The alternative would benefit 1,640 residences, 150 businesses, and 40 public facilities within the West Fargo/Riverside area. Also within this same area, approximately 8,400 persons would benefit. Because the standard project flood level of protection provided by the levees is greater than the base flood (1-percent chance flood) level, the area protected by these levees would no longer be classified as flood prone.

The effects of noise associated with the levee and diversion would be minimal. Construction activities would be limited to urban nonresidential and rural areas. In West Fargo, construction related noise would be audible only at a few isolated industrial firms where ambient noise levels are normally high. Noise levels might be temporarily increased by the movement of heavy equipment to and from the construction site and by detoured local traffic. Following construction, noise levels associated with the operation and maintenance of the diversion would be negligible.

Although construction of this alternative could increase immigration to West Fargo and Riverside, this effect is not anticipated. Both West Fargo and Riverside are experiencing significant increases in population because people working in Fargo and Moorhead locate there to take advantage of the lower tax base. A considerable amount of residential growth is also occurring in the floodplain of the Sheyenne River. A significant amount of this growth is taking place between Horace and West Fargo. However, the potential for flooding in these areas is not limiting new development at the present. Therefore, the protection provided by this alternative is not expected to result in any significant increases in development of floodplain areas.

Construction of the diversion alternative would somewhat alter the aesthetic character of the area. The streambed and banks of the Sheyenne River would remain unchanged. However, the character of the county ditch 21 area would be altered. The levee and diversion banks would probably be unsightly before seeding and vegetation. Grass cover would be maintained in the channel and on the levees. Once vegetated, the diversion might be perceived as an improvement over the existing unkept meadow and weed area. The levee would separate, visually as well as physically, the areas on either side of the existing ditch. The protection from flooding

could be interpreted as a benefit to aesthetic quality because it would prevent the visual deterioration of the area associated with the mud and debris temporarily present following flooding. The diversion may also provide an aesthetic benefit by lessening the deterioration of existing structures in the floodplain which are susceptible to periodic inundation. The area between the levees and other project lands could be developed into open space parks or incorporated into trail systems.

The diversion and levees around West Fargo would require modifications to a number of transportation routes. Traffic along U.S. Highways 10 and 52 would probably be funneled into a reduced number of lanes during the construction work on the affected bridges. A number of paved and unpaved country roads would also require bridge modifications, as would several city roads in West Fargo. Traffic along these roads would probably be detoured to alternate routes during construction. None of the roads or highways would be permanently closed, nor is it anticipated that any route would require large-scale relocation. The inconvenience associated with detouring and temporary lane closures is considered a negative impact of short duration. This inconvenience, however, should be weighed against the route closures which currently result from road inundations and washouts during floods when the delivery of emergency services along these routes is most critical. Following construction, the diversion and levee alternative should reduce the stress on emergency service deliveries during floods, resulting in better services to those requiring special assistance.

The levees and diversion alternative should benefit community cohesion by permitting the continued viability of those portions of West Fargo and Riverside susceptible to periodic large-scale flooding. The diversion would not bisect any existing neighborhoods, nor would it be likely to cause any intergroup conflicts. No common community meeting points would be relocated or disrupted, and no minority groups would be affected.

The diversion around West Fargo and Riverside would have a minimal impact on community growth. Development is presently occurring in floodplain areas along the river. This development has been stimulated by lower development costs and the protection against large-scale financial loss provided by flood insurance. Therefore, the security provided by the diversion and levees will probably not enhance growth in these areas. The levee and diversion system has, however, been designed to accommodate future growth.

The flood reduction benefits would also include protection of water supply and sewer systems in West Fargo and Riverside during floods.

This alternative would not impose costs on individuals or groups who would not benefit from it. Residents downstream of West Fargo believe this alternative could worsen their flood problems. However, the only appreciable change likely might be a slight increase in flood stages for a short distance upstream of the diversion. These upstream effects, although minor, will be evaluated in further detail in subsequent studies.

Approximately 65 acres of cropland and 264 acres of other types of land would be required for construction of the 1-percent chance flood design. The standard project flood design would require 70 acres of cropland and 309 acres of other types of land. The lands benefited by both plans are 1,700 acres urban and 1,800 acres of other types which include land within the leveed area currently used as cropland or vacant and which will most probably be developed for urban uses.

For the 1-percent chance flood design, flood damages at West Fargo/Riverside would be reduced 95 percent, which represents 65 percent of the total Sheyenne River flood damages. The standard project flood design would reduce flood damages at West Fargo/Riverside 98 percent, representing 68 percent of the total Sheyenne River damages.

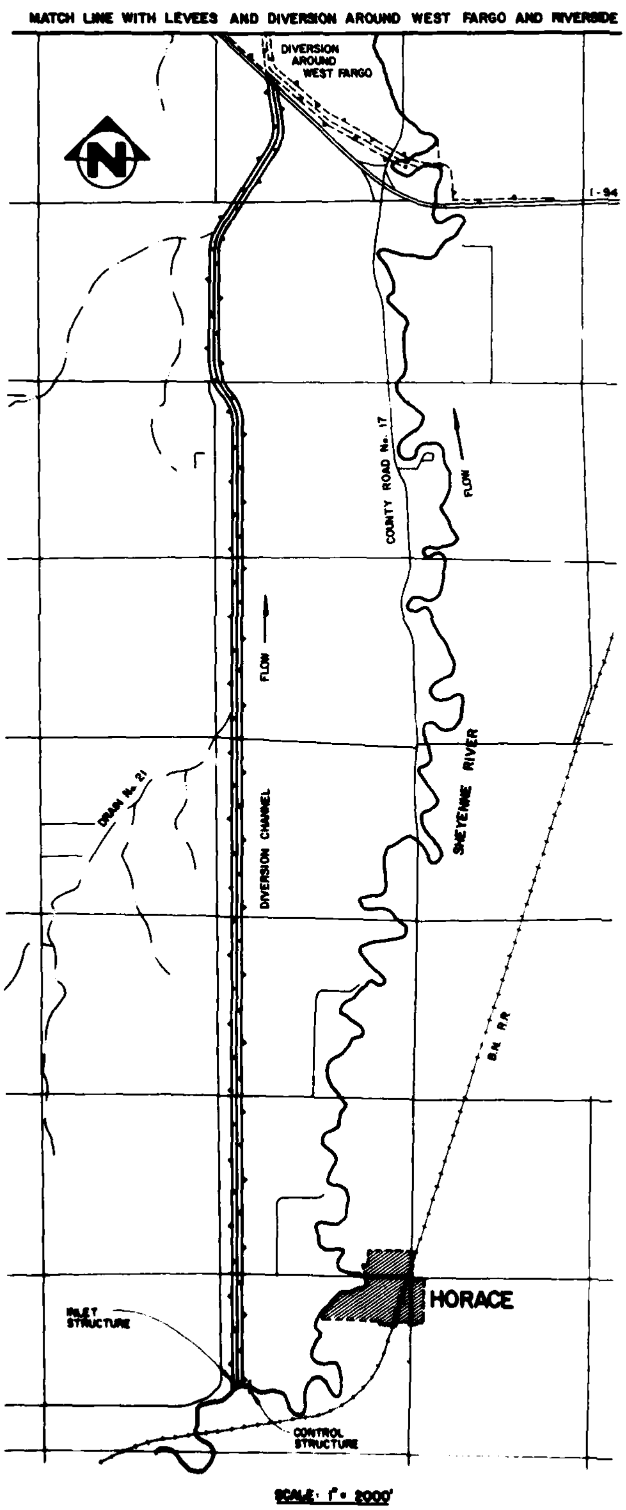
Although these alternatives would maintain flood levels within the channel at or near natural flood heights without the project, those areas protected by the alternative would have greatly reduced levels. With the average annual cost of $1.4 million for the 1-percent chance flood design and total benefits of $18.9 million for the same design, the benefit-cost ratio is 13.0. The standard project flood design average annual cost of $1.5 million and total benefits of $19.6 million also yield a benefit-cost ratio of 13. Both levels of protection are economically feasible.

Additional information on the interior drainage and hydraulic design features of the levees and diversion can be found in Appendix C; additional information on the strength of soils and slope stability can be found in Appendix K.

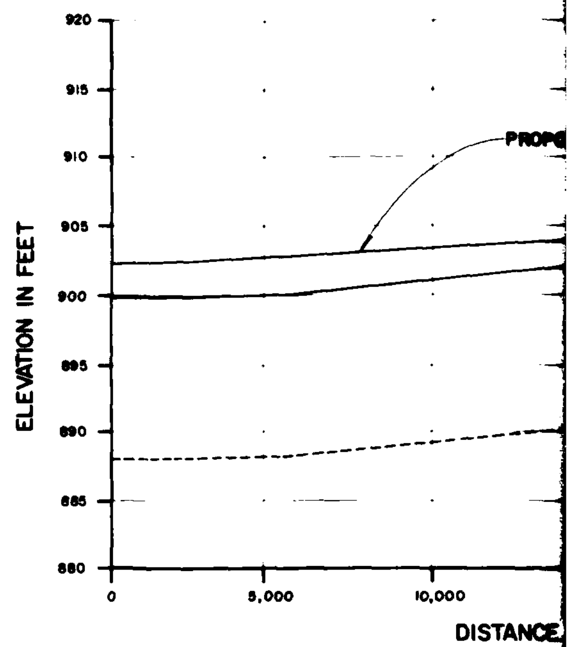
Flood Diversion, Sheyenne River from Horace to West Fargo (M-42 to M-29)

A flood diversion channel would reduce flood stages along the Sheyenne River from Horace to just upstream of West Fargo. The channel would start in Section 19 of Stanley Township about 1 mile southwest of Horace, proceed north paralleling the Sheyenne River, and join Cass County Drain No. 21. The diversion would follow Cass County Drain No. 21 to I-94 where it would join the proposed diversion and levee system around West Fargo/Riverside. The alignment and features are illustreated in figure L-12. This diversion would have to be an upstream extension of the M-29 to M-24 diversion alternative around West Fargo to be considered workable.

PLAN VIEW OF DIVERSION OF THE SHEYENNE RIVER
(HORACE TO WEST FARGO)



PROFILE OF SHEYE



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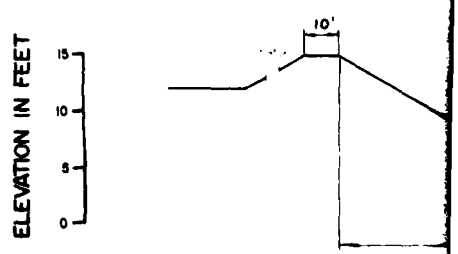

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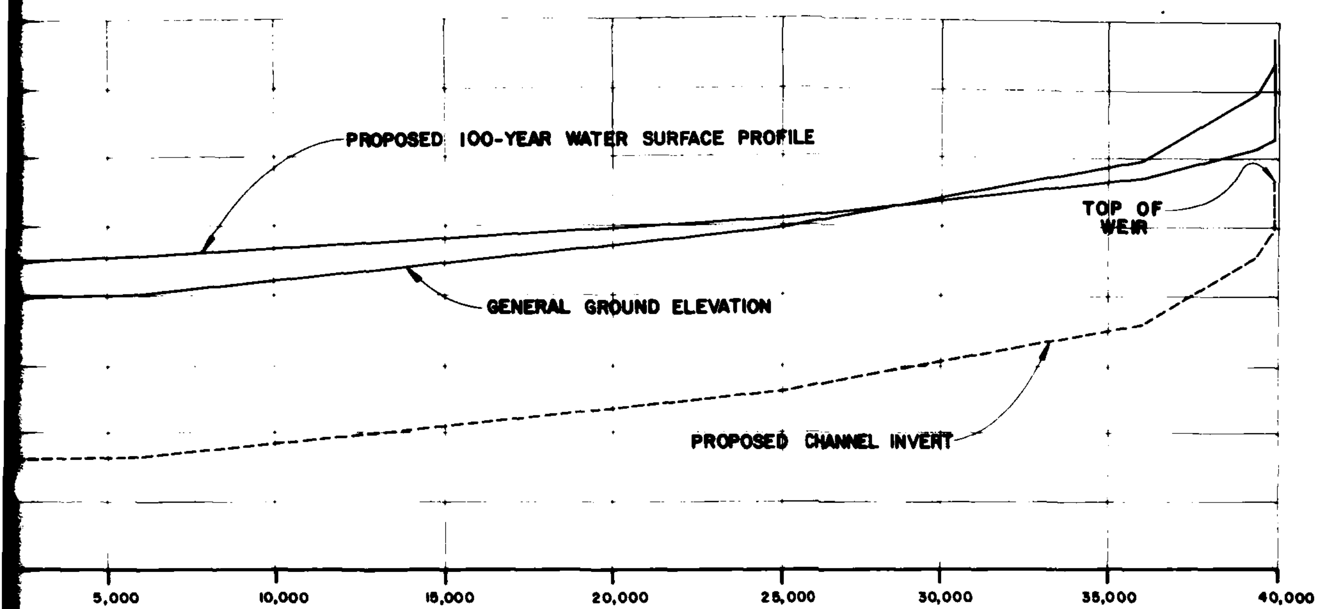
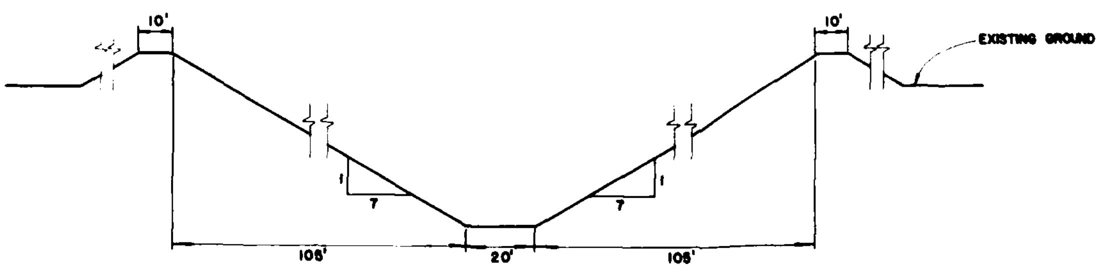
PROFILE OF SHEYENNE RIVER DIVERSION HORACE TO WEST FARGO



DISTANCE IN FEET FROM DIVERSION AROUND WEST FARGO

TYPICAL SECTION OF SHEYENNE RIVER DIVERSION HORACE TO WEST FARGO



GENERAL DESIGN MEMORANDUM-PHASE I
SHEYENNE RIVER, NORTH DAKOTA

DIVERSION OF THE SHEYENNE RIVER
(M-42 TO M-24)

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT

FIGURE L-12

JANUARY 1982

The diversion inlet structure, located just southwest of Horace, would be designed to pass low and normal flows along the natural channel of the Sheyenne River and divert a portion of the flood flows into the diversion channel. When flows would reach about 750 cfs just upstream of the inlet structure, some water would be diverted. As the flows increase, the amount of water entering the diversion channel would also increase. When flows would reach about 3,400 cfs (comparable to the 1979 flood flows), about half of the flow would be diverted into the diversion channel. The diversion channel would be designed to handle a flow of 1,700 cfs. At Horace, river levels during a major flood (such as the 1979 flood) would be lowered by about 3½ feet. The inlet structure would be designed to ensure that water levels on the upstream side of the inlet would not be lowered so that the flows entering the diversion and river would not be greater than flows along the river under preproject conditions. Pertinent information on the flood diversion channel is shown in table L-16.

The first cost of this alternative is about $8.1 million, representing an average annual cost of $706;300. An estimated $1,383,000 in average annual flood control benefits would accrue in the reach from Horace to West Fargo.

This alternative would have to be coupled with the M-29 to M-24 diversion. It would reduce flood damages between Horace and West Fargo, resulting in a 5-percent reduction in total Sheyenne River flood damages. With an average annual cost of $706,300 and total average annual benefits of $1,383,000, this alternative's benefit-cost ratio is 1.9, with average annual net benefits of $676,700.

The level of flood protection and full estimate of benefits provided by the flood diversion channel in the reach from Horace to West Fargo cannot be precisely established, partly because of the uncertainties about the specific local agricultural levees upstream that would be overtopped and/or fail during floods larger than the 2-percent chance event.

The benefits have been fully credited for up to the 2-percent chance level flood at Horace and for the non-urban residential developments in the reach. For events greater than the 2-percent chance flood, the diversion would provide additional benefits, but the reductions may not be sufficient to reduce the flood stages to non-damaging levels in all reaches. For floods larger than the 2-percent chance event, the potential for damages during any given flood in the protected reach exists if certain upstream rural levees would be overtopped and/or fail. Although additional benefits could be claimed, these benefits represent less than 10 percent of the total benefits to be gained, and the justification needed to claim this additional amount is not easily documented. These additional benefits are not needed to demonstrate economic feasibility. Private levees that parallel the Sheyenne River from Kindred to Horace upstream of the inlet to the flood diversion channel affect the location and direction of breakout flows. Major breakouts have occurred both to the east and to the west. Breakouts that go to the east enter drainage patterns which end up in either the Wild Rice River or the Red River of the North. For events smaller than the 2-percent chance event, such breakouts do not pose any significant threat to the developments along the Sheyenne River from Horace to West Fargo. Breakout flows that go to the west enter one of several county drain systems which eventually rejoin either the Sheyenne River or the Maple River near or north of West Fargo. For floods of the magnitude of the standard project flood, most of the breakout flows go to the west and rejoin the Maple River northwest of West Fargo.

Breakout flows generally do not reenter the Sheyenne River because the banks of the Sheyenne are higher than the surrounding ground. The course of the breakout flows is guided by the various road and railroad embankments that cross the area. The specific direction and location of the breakout flows depend upon which section of private levee is overtopped and/or fails. The east-west county road about 1 mile south of Horace and the Burlington Northern Railroad embankment that passes through Horace are the greatest barriers to any breakout flows that might threaten

(R 3/18/83)

Horace from the east and immediately upstream of Horace. Regulation of the private levees upstream of Horace is essential for proper functioning of the flood diversion channel. Future regulation of the floodplain should also consider the roles that the roadway and railroad embankments serve as levees and flow diverters.

The sizing of the diversion channel was selected because of the relatively high degree of protection and stage reductions that it provides in the reach from Horace to West Fargo. For smaller flood diversion channels, the effectiveness of the channel for flood damage reduction falls off rapidly. For example, a 1000 cfs channel would result in a 40-percent decrease in benefits with a level of protection of about the 10-percent chance event. Although the costs of the smaller diversion channel would be less, net benfits would probably be significantly less because many costs such as road and bridge removal costs and land costs are not reduced on the same scale as the benefits of a smaller channel are decreased.

To provide for assured higher levels of protection with the diversion channel, levees must be added to the plan, and interior drainage features such as ponding areas, gated culverts, and possible pumping stations also must be added in some areas. Addition of these features most likely would decrease net benefits. However, future detailed design studies should consider further economic evaluation to determine the optimum point of net benefits. Based on the uncertainties of location of upstream breakouts and the large amount of benefits achieved with the selected size, the selected channel size is probably very close to the economic optimum. If the more detailed evaluations determine that greater net benefits are possible without a significant reduction in the degree of flood protection provided or without an increase in the adverse social and environmental impacts of the channel, the channel size should be modifed to achieve the greater net benefits.

Table L-16 - Pertinent information: flood diversion channel from Horace to West Fargo (M-42 to M-29)

Item	Amount
<u>Pertinent data</u>	
Design discharge (cfs)	1,700
Channel	
Bottom width (feet)	20
Top width (feet)	200-230
Length (miles)	7.6
Average depth (feet)	10-12
<u>Economics</u>	
Cost	
First cost ($millions)	8.1
Average annual cost ($1,000)	706
Benefits	
Flood control ($1,000)	
West Fargo	--
Valley City	0
Agricultural (Sheyenne River)	30
Other	1,353
Subtotal flood control ($1,000)	1,383
Benefit-cost ratio	1.9
Net benefits ($1,000)	677
<u>Social effects</u>	
Properties, farmsteads, businesses, etc., acquired	0
Properties benefited	
Farmsteads and residences	330
Businesses	11
Public facilities	5
Persons relocated	0
Persons benefited[(1)]	1,000
Lands required (acres)	
Cropland	145
Other	105

Table L-16 - Pertinent information: flood diversion channel from Horace to West Fargo (M-42 to M-29)(cont)

Item	Amount
Lands benefited (acres)	
Cropland	6,000
Urban	100
Other	--
Transportation - roads severed	0
Flood damage reduction effectiveness	
Reduces total flood damages (percent)	
Valley City	0
West Fargo	--
Total Sheyenne River	5
Reduces 1-percent chance flood level	
Valley City	0
West Fargo	(2)

(1) Benefited by reduced flood damages.

(2) Flood heights at West Fargo within the channel will be at or near natural flood heights without the project. However, those areas protected by the alternative between Horace and West Fargo will have their flood levels reduced by several feet.

The diversion channel would be about 7½ miles long with a bottom width of 20 feet and an average depth of about 10 to 12 feet by the time it reached the M-29 to M-24 diversion. The earth removed during construction would be placed on the overbank areas.

This alternative would have little impact on the environment in comparison with other flood control alternatives. A summary of the impacts associated with this alternative can be found in table L-17. The most valuable habitat in the lower basin is the riparian woodland. The surrounding land use is predominantly agricultural, and the area has been classified as prime farmland by the Soil Conservation Service.

The riparian woodlands provide habitat for deer and semiaquatic organisms and are a valuable transition area for migrating birds. The woodlands are essential to the wintering deer herds in the lower basin. Loss of the woodland could be mitigated by plantings along the diversion right-of-way. Enhancement opportunities are available through purchase of permanent instead of temporary easements along the diversion and planting of vegetation or windbreaks in these areas. The windbreaks would provide wildlife habitat and could be designed to reduce snow accumulation in the diversion channel.

This alternative would be located near the extreme downstream end of the Sheyenne River segment identified as having potential for inclusion in the Wild and Scenic River System and, therefore, would have

potentially less serious impacts than would other alternatives upstream. However, the riprapping and shaping of the diversion channel and the Sheyenne River diversion entry point would constitute an obvious intrusion by man and would, therefore, have a negative impact.

This alternative would not involve the acquisition of any farmsteads, residences, businesses, or public facilities. The diversion would benefit 330 farmsteads and residences, 11 businesses, and 5 public facilities. Also within the same area, between Horace and West Fargo, about 1,000 persons would benefit.

The effects of noise associated with the diversion would be minimal. Construction activities would be limited to nonresidential and rural areas. There may be a slight temporary increase in the level of noise generated by the movement of heavy equipment to and from the construction site and by detoured local traffic.

A considerable amount of residential growth is occurring in the floodplain of the Sheyenne River. A significant amount of this growth is taking place between Horace and West Fargo. However, the potential for flooding in these areas is not limiting new development at the present. Therefore, the protection provided by this alternative is not expected to result in any significant increases in development of floodplain areas.

Farming practices could be hampered by the Horace to West Fargo diversion because the diversion would cut diagonally across some field sections. Therefore, farmers along the diversion route would lose some portions of their productive farmland. If the acquisition of a portion of a farm would leave its owner with an uneconomic remnant, an offer to acquire the entire property would be made.

Table L-17 - Summary of impacts: diversion from Horace to West Fargo (M-42 to M-29)

Item	Impact
Habitat	
Woodland	About 4 acres used by deer and other wildlife.
Cropland	45 acres.
Grassland	40 acres.
Wetland	Some affected on ditch bottom of existing drain.
Fish	No impact.
Miscellaneous	
Rare plants and animals	No effect.
Water quality	Temporary increase in turbidity during construction.
Aesthetics	Adverse effects during construction.
Planning constraints	
E.O. 11988 (Floodplains)	This alternative would be built in the floodplain and could change land use and nature of future developments.
E.O. 11990 (Wetlands)	Minor. Some wetland type habitat is in existing ditch bottom.
Preserve riverine environment	Minimal effect on riverine environment.
Federal threatened and endangered species	None known.
Federal and State wild and scenic rivers	The diversion channel is an intrusion by man and, therefore, is a negative impact. Would be located at downstream end of proposed river segment.
Areas of critical national importance	
Game management areas, refuges, grasslands, etc.	No effect.
Cultural resources	No effect on any known cultural resources; undetected resources could be affected.

Construction of the diversion alternative would somewhat alter the aesthetic character of the area. Although the streambed and banks of the Sheyenne River would not be changed, the character of the county ditch 21 area would be altered. The diversion banks would probably be unsightly before seeding and vegetation. The protection this alternative would afford from flooding would benefit aesthetic quality because it would prevent the visual deterioration of the area associated with the mud and debris temporarily present following flooding. The diversion may also lessen the deterioration of existing structures in the floodplain which are susceptible to periodic inundation.

The diversion from Horace to West Fargo would temporarily sever transportation along several gravel roads during construction. Two of the seven county roads cut by the diversion would have bridges constructed while the remaining five would have Texas crossings constructed. While the roads are closed, access to farm fields would be hampered.

Following construction, the diversion should reduce the stress on emergency service deliveries during floods, resulting in better services to those requiring special assistance.

The diversion should benefit community cohesion by permitting the continued viability of those portions of the West Fargo and Horace communities susceptible to periodic large-scale flooding. The diversion would not bisect any existing neighborhoods, nor do any inter-group conflicts seem probable. No common community meeting points would be relocated or disrupted by this alternative, and no minority groups would be affected.

The diversion from Horace to West Fargo would have a minimal impact on community growth. Development is occurring in floodplain areas along the river because of lower development costs and the protection against large-scale financial loss provided by flood insurance.

Modifications to existing highways and roads during construction could create some emergency service delays and additional hazards if traffic rerouting during construction was not handled efficiently. Any major impediments to emergency service delivery or increases in traffic accidents could be avoided through an adequate program of notification of delays or detours, staggered construction of parallel routes, and planned emergency vehicle rerouting.

The diversion from Horace through West Fargo would impose added costs on some farmers in the form of additional acres taken out of production, while residents living along the river would receive the benefits of flood protection. The farmers would be reimbursed for their land; however, the level of distributive equity would depend on the farmers' perception of the adequacy of the terms of reimbursement for their land and the inconveniences that would result. This alternative when considered by itself and acting alone may also impose costs on residents and farmers downstream of West Fargo by slight potential increases in peak flood stages in these areas. This impact would vary, depending on the specific flood; however, the effect would be in the range of about 0.1 to 0.2 foot (or about 1 inch). Although this increase could constitute a negative effect on both distributive equity and life, health, and safety, it would be a relatively minor impact. Nevertheless, the downstream residents would be very concerned about any potential increases in flood levels. To offset this potential impact, other flood damage reduction measures, such as upstream flood control storage, could be added to the overall flood damage reduction plan.

Baldhill Dam (Raise of Dam)

The earth-fill structure at Baldhill Dam would be raised to provide additional flood storage capacity. The existing dam on the Sheyenne River approximately 16 miles upstream of Valley City, North Dakota, would be used as the base for construction of the larger dam. A new emergency spillway and control structure, additional land, and a raised embankment would be required. To comply with the Federal Dam Safety Program, the existing structure would need some structural upgrading. The upgrading is considered a part of the "future without" project condition and could be accomplished independent of the raise for flood control. However, because the upgrading and raise for flood control are both being considered at this time, they should be implemented together. During preliminary evaluations, several levels of raises were considered. Pertinent data for these conditions are contained in table L-18. During the final evaluations, only raises up to 5 feet were considered. A summary of pertinent data for a 5-foot raise, including a comparison of the future without condition when only the structure upgrading would be accomplished, and the existing condition is presented in table L-19. Figures L-13, L-14, and L-15 show a plan view of Lake Ashtabula with the existing Federal property line, existing lakeshore, and areas of potential land acquisition for raised conditions.

Table L-18 - Pertinent information on raises of Baldhill Dam(1)

Item	Height of raise: 5 feet	10 feet	15 feet	20 feet	25 feet
Pertinent data					
Additional storage (acre-feet)	31,400	65,000	105,000	153,000	210,000
Height of dam (feet)	43	48	53	58	63
Elevations (feet above msl)					
Top of dam	1283	1288	1293	1298	1303
Design flood pool	1271	1276	1281	1286	1291
Normal pool	1266	1266	1266	1266	1266
Spring drawdown level	1257	1257	1257	1257	1257
Lowest outlet level	1238	1238	1238	1238	1238
Lands (acres)					
Flooded at design flood pool	1,010	2,230	3,550	4,970	6,490
Lands to be acquired(2)	2,700	5,600	8,400	10,600	13,300
Economics					
Costs					
First cost ($ million)(3)	9.1	20-30	30-40	40-50	45-55
Average annual cost ($1,000)	768	2,200	2,900	3,800	4,400
Flood control benefits ($1,000)(5)	1,454	1,690	1,830	1,960	2,050
Benefit-cost ratio	1.9	0.8	0.6	0.5	0.5
Net benefits ($1,000)	686	-510	-1,070	-1,840	-2,350
Environmental effects (with design flood pool)					
Woodland					
Acres	170	395	675	965	1,450
Percent of total affected	8	22	37	53	80
Grassland					
Acres	230	500	885	1,260	1,620
Percent of total affected	6	21	37	53	68
Wetland					
Acres	560	675	840	980	1,090
Percent of total affected	35	50	63	73	81
Cropland					
Acres	240	660	1,150	1,765	2,325
Percent of total affected	7	20	35	54	71

Table L-18 - Pertinent information on raises of Baldhill Dam[1] (cont)

Item	Height of raise 5 feet	10 feet	15 feet	20 feet	25 feet
Environmental effects (cont)					
Mitigation lands required (acres)	450	1,500	2,500	2,900	3,600
Miles of river affected	3	8	13	16	20
Rare species affected	Yes	Yes	Yes	Yes	Yes
Threatened and endangered species affected	None known	None known	None known	None known	None known
Areas of national importance affected	Yes	Yes	Yes	Yes	Yes
Wild and scenic river affected	No	No	No	No	No
Additional lands affected by infrequent floods (acres)	1,220	1,320	1,420	1,520	640
Additional river miles affected	5	5	3	4	2
Aesthetic qualities affected	Yes	Yes	Yes	Yes	Yes
Social effects					
Properties acquired					
Farmsteads and residences (at upper end)	6	13	21	21	21
Cabins and dwellings (around lake)	97	170	180	190	190
Other	4	5	7	7	7
Properties benefited(6)					
Farmsteads and residences	790	790	790	790	790
Businesses	70	70	70	70	70
Public facilities	2	2	2	2	2
Persons relocated(7)	15	39	63	63	63
Persons benefited(8)	2,350	2,350	2,350	2,350	2,350
Lands benefited (acres)(9)					
Cropland	23,350	23,250	23,250	23,250	23,250
Urban	100	100	100	100	100
Other	-	-	-	-	-
Transportation - roads severed	0	0	0	0	0
Cultural resource sites	20	23	34	35	43

Table L-18 - Pertinent information on raises of Baldhill Dam[1] (cont)

Item	Height of raise				
	5 feet	10 feet	15 feet	20 feet	25 feet
Flood damage reduction effectiveness					
Reduces total flood damages (percent)					
Valley City	66	78	84	89	92
West Fargo	(10)	(10)	(10)	(10)	(10)
Reduces 1-percent chance flood level at Valley City	Yes	Yes	Yes	Yes	Yes

(1) Data presented for the 10- through 25-foot raises were not developed to the same level of detail as the data for the 5-foot raise.

(2) Additional lands beyond those already owned by the Government. This figure also includes fish and wildlife mitigation lands.

(3) Estimates of first costs are based on costs allocated to flood control. Costs credited to structural upgrading, which could range from $15.2 to $22 million, are not included in the estimate.

(4) Average annual costs of $1,428,000 are estimated for the higher first cost of $16.8 million. For a first cost of $9.1 million, the average annual cost would be $767,700.

(5) Benefits were estimated for Valley City and Lisbon. Additional flood control benefits would be gained in the rural reaches from Valley City to Kindred. Benefits downstream of Kindred could also be credited, particularly if the raises of Baldhill Dam are considered as taking effect after the Dead Colt Creek dam is in place. The additional benefits from Kindred to West Fargo could range from $500,000 to $800,000.

(6) Figures reflect properties in Valley City and Lisbon. However, additional properties would benefit in the rural reaches from Baldhill Dam to Kindred. Additional benefits for the second peak would be received from properties located downstream of Kindred.

(7) Based on an estimate of three persons per residence.

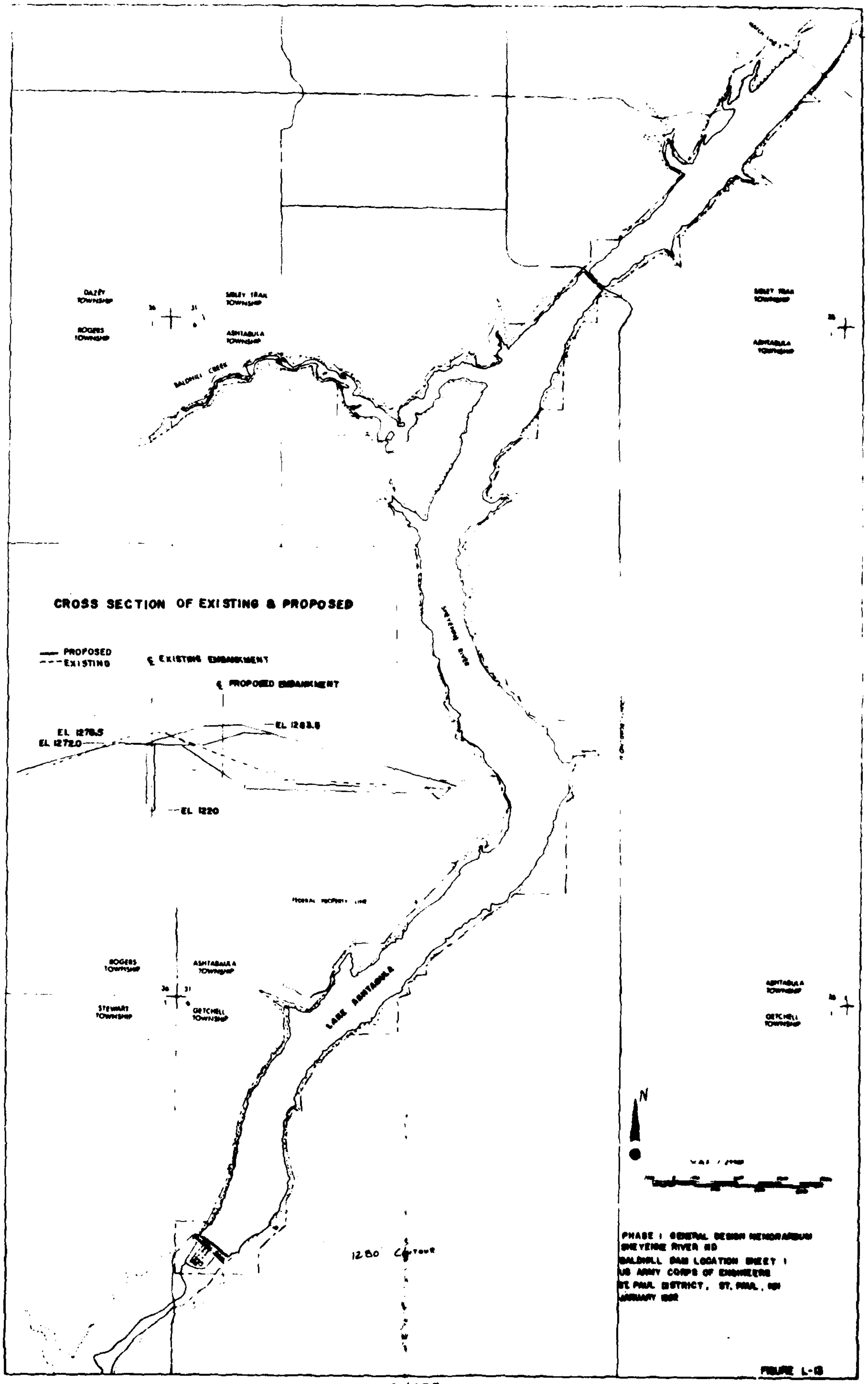
(8) Would benefit from reduced flood damages. Does not include the area downstream of Kindred.

(9) Lands benefited do not include lands downstream of Kindred which would receive benefits from reduction of the second peak.

(10) Benefits at West Fargo are not quantified because the first peak at West Fargo would not be reduced; only the second peak would be affected.

Table L-19 - Comparison of 5-foot raise of Baldhill Dam with existing and future without project conditions

Item	Existing condition	Future without project condition (includes structural upgrading	5-foot raise
Raise in feet	--	--	5
Storage (in acre-feet)			
Water conservation	67,800	67,800	68,300
Flood control (dual use)	39,600	39,600	39,600
Flood control (exclusive)	--	--	31,400
Total storage	68,600	68,600	100,000
Elevations (feet above msl)			
Top of dam	1278.5	1278.5	1283.5
Design flood pool	1266.0	1266.0	1271.0
Normal pool	1266.0	1266.0	1266.0
Spring drawdown level	1257.0	1257.0	1257.0
Lowest outlet level	1238.0	1238.0	1238.0
Lands (acres)			
Permanent pool	5,430	5,430	5,430
Flood pool	5,430	5,430	6,200
Federally-owned land	8,483	8,483	11,200
Spillway/control structure			
Number of gates	3	5	5
Use of existing spillway	Yes	Yes	Yes
Construct additional spillway	No	Yes	Yes
Design discharge for spillway (cfs)	43,100	126,000	126,000
Estimated first cost of construction ($million)	—	$22.0	$31.1



DAZEY TOWNSHIP
SIBLEY TRAIL TOWNSHIP
ROGERS TOWNSHIP
ASHTABULA TOWNSHIP
BALDHILL CREEK
CROSS SECTION OF EXISTING & PROPOSED
PROPOSED
EXISTING
℄ EXISTING EMBANKMENT
℄ PROPOSED EMBANKMENT
EL 1276.5
EL 1272.0
EL 1220
ROGERS TOWNSHIP
ASHTABULA TOWNSHIP
STEWART TOWNSHIP
GETCHELL TOWNSHIP
LAKE ASHTABULA
1280 Contour
N
PHASE I GENERAL DESIGN MEMORANDUM
SHEYENNE RIVER ND
BALDHILL DAM LOCATION SHEET 1
US ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT, ST. PAUL, MN
FIGURE L-13

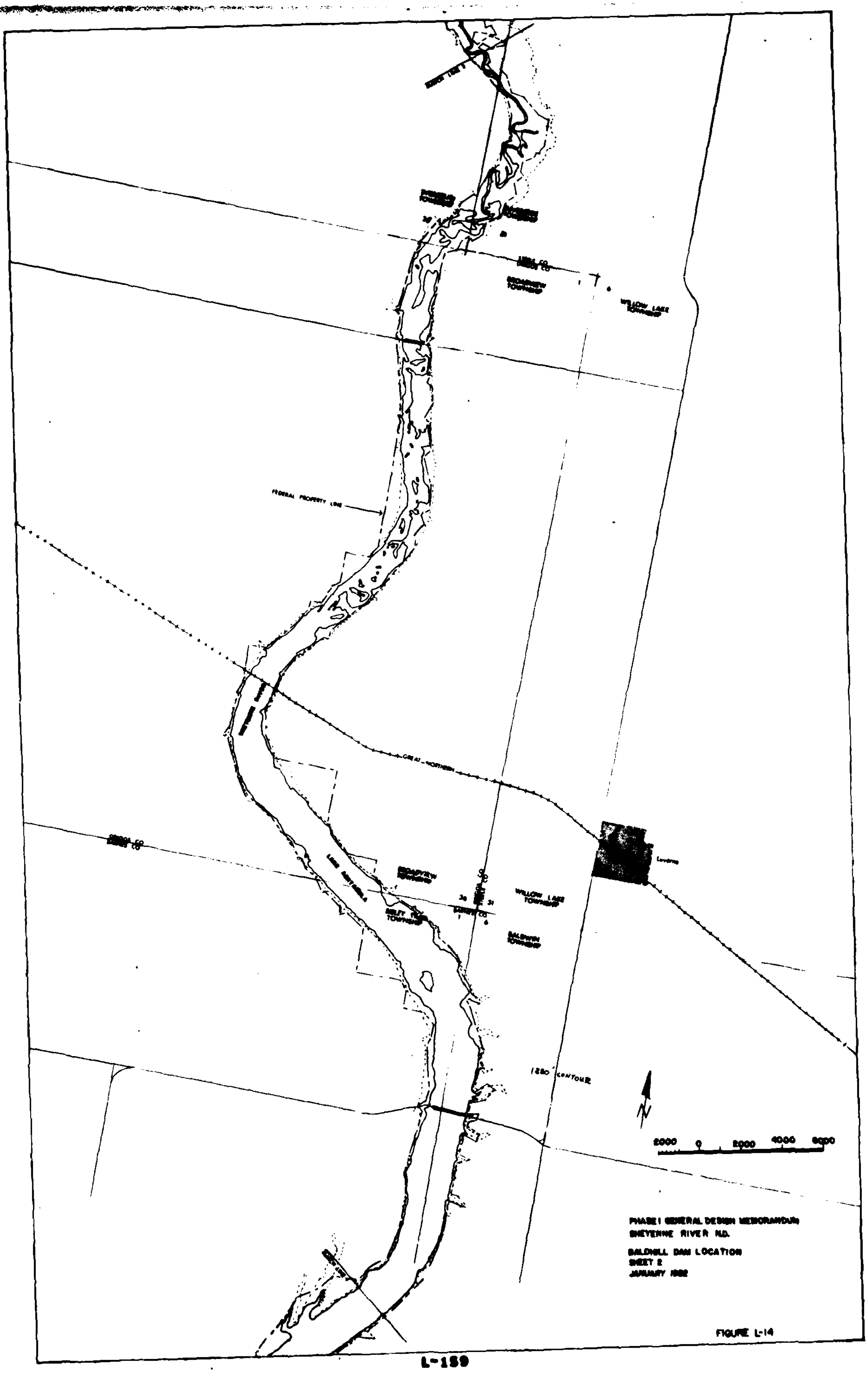
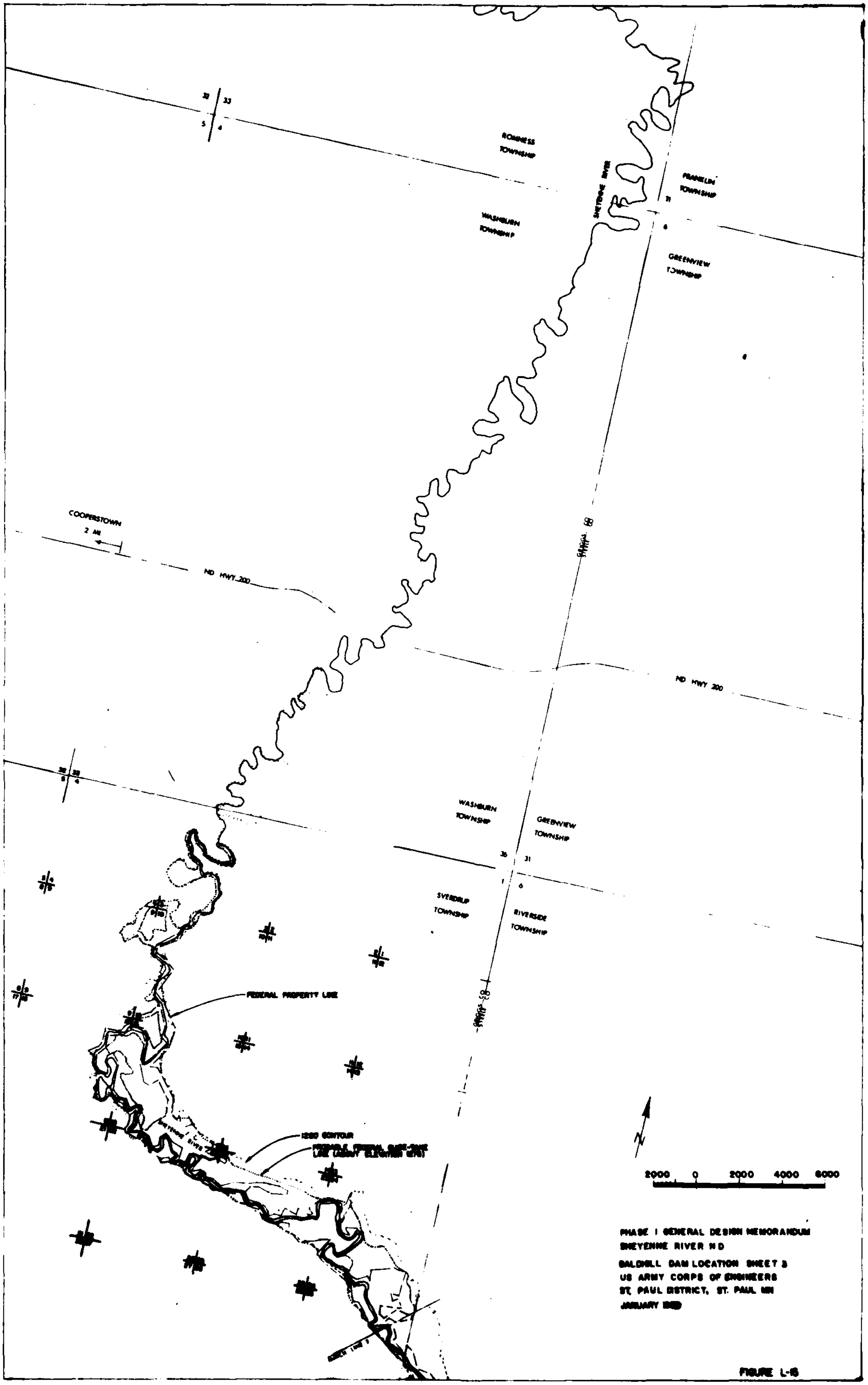

FEDERAL PROPERTY LINE
GREAT NORTHERN
BROADVIEW TOWNSHIP
WILLOW LAKE TOWNSHIP
BALDWIN TOWNSHIP
1280' CONTOUR
N
2000 0 2000 4000 6000
PHASE I GENERAL DESIGN MEMORANDUM
SHEYENNE RIVER N.D.
BALDHILL DAM LOCATION
SHEET 2
JANUARY 1982

FIGURE L-14



ROMNESS TOWNSHIP
WASHBURN TOWNSHIP
FRANKLIN TOWNSHIP
GREENVIEW TOWNSHIP
COOPERSTOWN
2 MI
ND HWY 200
ND HWY 200
WASHBURN TOWNSHIP
GREENVIEW TOWNSHIP
SVERDRUP TOWNSHIP
RIVERSIDE TOWNSHIP
FEDERAL PROPERTY LINE
2000 0 2000 4000 6000
PHASE I GENERAL DESIGN MEMORANDUM
SHEYENNE RIVER ND
BALDHILL DAM LOCATION SHEET 3
US ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT, ST. PAUL MN

FIGURE L-16

The permanent pool would remain at the current elevation (1266 feet msl); however, the operating plan would be modified to use the storage above the permanent pool level for flood control only. Releases of water from the permanent pool during nonflood periods would remain similar to those of the current operation, with the spring drawdown of the pool level as low as elevation 1257 when high runoff is anticipated.

The top of the existing dam is approximately elevation 1278. Therefore, the 5- to 25-foot raises would increase the top of the earth embankment to elevations ranging from about 1283 to 1303 feet msl. The additional storage for a 5-foot raise would be about 31,400 acre-feet and would increase proportionally to 210,000 acre-feet for a 25-foot raise. The additional land that would need to be acquired would range from 2,700 acres for the 5-foot raise to 13,300 acres for the 25-foot raise. This land also includes fish and wildlife mitigation land.

The first costs of this alternative would range from $9.1 million for the 5-foot raise to $45 to $55 million for the 25-foot raise. The cost of structural upgrading for the existing structure would be about $22.0 million. This cost is allocated to structural upgrading, and the remaining costs are allocated to flood control. The average annual costs for flood control would range from $768,000 for the 5-foot raise and to about $4.4 million for the 25-foot raises.

Flood control benefits would be gained downstream of the dam, with the greatest reductions in flood levels occurring at Valley City. Proceeding downstream of Valley City, the reductions in flood levels would come on the second peak at Lisbon, Kindred, West Fargo, and other locations. Because this raise would only be partially effective in reducing flood levels downstream of Kindred, the estimated average annual flood control benefits were quantified primarily for Valley City, Lisbon, and the other reaches from Baldhill Dam to Kindred. They range from $1.45 million for the 5-foot raise to $2.05 million for the 25-foot raise.

The benefit-cost ratios for the various raises range from 1.9 for the 5-foot raise to 0.5 for the 25-foot raise if the ratios consider only the benefits gained at Valley City and Lisbon. If all downstream benefits were quantified, the benefit-cost ratios would be greater.

Preliminary estimates of the average annual additional flood control benefits in the reach from Kindred to West Fargo creditable to a 5-foot raise would range from $500,000 to $800,000. These additional benefit estimates consider the Dead Colt Creek dam as in place and functioning with the raise of Baldhill Dam. This situation would result in a benefit-cost ratio of about 2.8. Since these benefits represent a substantial increase from those presented in table L-18, the quantification of these benefits should be refined in subsequent detailed engineering studies. This refinement could be particularly important for cost-sharing purposes.

Maximum average annual net benefits would be obtained with the 5-foot raise of Baldhill Dam when the benefits at Valley City, Lisbon, and rural reaches between Baldhill Dam and Kindred are considered. In later, more detailed design studies, further refinement of the evaluation optimizing the net benefits of the raise of Baldhill Dam should be considered. If the net benefits can be increased by such further refinement without appreciably reducing the level of flood protection provided and without causing adverse social and environmental impacts greater than those of the 5-foot raise condition, then the raise that provides greater net benefits should be implemented. During the optimizing evaluation, the operating plan for the dam should also be evaluated in greater detail, to assure that the plan will obtain the optimum combination of benefits, costs, social and environmental impacts, and level of flood protection.

Table L-20 summarizes the impacts of raising Lake Ashtabula. The narrative that follows is a preliminary evaluation of these impacts as determined through a review of pertinent literature, field surveys, public meetings, and conversations with representatives of natural resource agencies.

Table L-20 - Summary of impacts associated with raising Baldhill Dam

Item	Impact				
	5-foot raise (elevation 1271)	10-foot raise (elevation 1276)	15-foot raise (elevation 1281)	20-foot raise (elevation 1286)	25-foot raise (elevation 1291)
Habitat					
Woodland	This alternative would affect 170 acres of woodland that are heavily used by deer for winter cover and food. There is heavy use by other wildlife also, mostly because of the scarcity of woodland in the area. Most of the impacts are located upstream. Many areas are heavily grazed. Infrequent floods would affect an additional 215 acres of woods.	Design pool would affect 395 acres; infrequent floods an additional 250 acres. Affects about 25% of woodland in area.	Design pool would affect 675 acres; infrequent floods an additional 275 acres.	Design pool would affect 965 acres; infrequent floods an additional 305 acres. Affects about 50% of woodland in area.	Design pool would affect 1,450 acres; infrequent floods an additional 130 acres.
		Impacts of these higher pool levels are similar to the elevation 1271 pool except that the extent and magnitude of the impacts increase and become more significant. The higher pools affect a larger portion of the habitat and become less desirable environmentally.			
Cropland	Design pool would affect about 240 acres; infrequent floods another 365 acres.	Design pool would affect 660 acres; infrequent floods another 425 acres.	Design pool would affect 1,150 acres; infrequent floods another 505 acres.	Design pool would affect 1,765 acres; infrequent floods another 555 acres.	Design pool would affect 2,325 acres; infrequent floods another 235 acres.
	In most areas, wildlife use is very light. There is some feeding by birds and rodents. They, in turn, are prey species for other forms of wildlife. There is an abundance of cropland in the area and outside the river valley. Fish and wildlife impacts resulting from cropland loss are not significant.				
Grassland	Design pool affects 230 acres; infrequent floods another 275 acres.	Design pool affects 500 acres; infrequent floods another 330 acres. Affects about 25% of grassland in area.	Design pool affects 885 acres; infrequent floods another 360 acres.	Design pool would affect 1,260 acres; infrequent floods another 395 acres. Affects about 50% of grassland in area.	Design pool would affect 1,620 acres; infrequent floods another 170 acres.
	Grassland use is moderate mostly because of heavy grazing. Therefore, grassland generally has lower habitat value compared to downstream. As pool levels increase, the impacts become greater as a larger proportion of the grassland habitat in the area is affected. Although much of the grassland is of relatively poor quality mostly as a result of grazing pressures, it provides habitat for birds, mammals, and other wildlife and is important because of its interspersion with other habitat types.				
Wetland	Design pool affects 560 acres; infrequent floods another 365 acres.	Design pool affects 675 acres; infrequent floods another 315 acres. Affects about 25% of wetland in area.	Design pool affects 840 acres; infrequent floods another 280 acres.	Design pool affects 980 acres; infrequent floods another 265 acres. Affects about 50% of wetland in area.	Design pool affects 1,090 acres; infrequent floods another 105 acres.
	Wetlands in this area usually provide good to excellent habitat for aquatic furbearers and some bird species. Most oxbows are relatively large, with permanent water. Some of the marsh areas and oxbows are excellent habitat. As the pool level increases, more habitat is affected and the impact becomes more significant.				
Fish	3 river miles affected.	8 river miles affected.	13 river miles affected.	16 river miles affected.	20 river miles affected.
	Walleye, northern pike, perch, suckers, bullheads, and other species are found in the river. A large recreational fishery is associated with the reservoir. Some river fishing also exists. No long-term impacts other than those discussed under water quality would be expected. Short-term impacts such as death of some invertebrate populations would occur.				
Miscellaneous					
Rare plants and animals	2 species may be affected. A sedge and pondweed, both rare in North Dakota, are found near the reservoir.	Same as for 5-foot raise.	Same as for 5-foot raise.	Same as for 5-foot raise.	Same as for 5-foot raise.
Water quality	Temporary increases in turbidity would result. Sedimentation would occur in flood pool. Higher flood pools could increase erosion and sedimentation. Depending on the amount, this could cause adverse impacts to fish, wildlife, vegetation, and aesthetics. Weedy species would probably invade the silted and frequently flooded areas, creating less valuable habitat.				
Aesthetics	The aesthetic impacts are associated with the vegetation, wildlife, and topographic features. The raise would result in long-term impacts. Existing riparian vegetation would be destroyed in many areas because of long inundation. The distinctive valley and coulee landscape would be inundated up to 120 days. A temporary rise may create new opportunities for viewing wildlife. Loss of habitat and regrowth of less desirable vegetation would affect wildlife populations adversely.				
Planning constraints					
E.O. 11988 (Floodplain)	The project would modify some floodplain lands and possibly change the nature of future developments downstream. The amount of floodplain lands affected and probability of modifying development patterns increases with pool raises.				
E.O. 11990 (Wetlands)	Pool raises would affect some excellent wetland habitat. Modified sedimentation patterns would affect wetland areas. Magnitude and significance increase with higher pool levels.				
Preserve riverine environment	Modifies some river environment by destroying some vegetation and wildlife and creating less desirable weedy vegetation.	The higher pool levels have a much more significant impact on the river environment because of the longer reach of river affected, higher elevation, and longer duration of flooding. The magnitude of the impact on vegetation, wildlife, and aesthetics increases drastically with pool level.			
Federal threatened and endangered species	None known	None known	None known	None known	None known
Federal and State wild and scenic rivers	Project is not in an area selected for possible inclusion in either the Federal or State Wild and Scenic River System.	Same as for a 5-foot raise.	Same as for a 5-foot raise.	Same as for a 5-foot raise.	Same as for a 5-foot raise.
Areas of critical national importance					
Game management, refuges, National Grasslands, etc.	The flood pool would affect State game management areas and State game refuge adjacent to Lake Ashtabula. Less desirable weedy species of vegetation would probably invade the flood pool.	The impacts increase with pool levels because of longer durations of inundation and larger acreages affected.			
Cultural resources	20 known sites are located at or below elevation 1271.	23 known sites are located at or below elevation 1276.	34 known sites are located at or below elevation 1281.	35 known sites are located at or below elevation 1286.	43 known sites are located at or below elevation 1291.
	It should not be assumed that these raises in pool elevation would only affect the number of sites listed above. Erosion from waves and fluctuation in pool level may affect sites above the maximum raise. For example, a 20-foot raise would affect 35 known sites, but erosion could also affect another 8 sites between elevation 1286 and 1291. Expanding recreation areas around existing Lake Ashtabula and in upstream reaches may also affect cultural resources. Road and utility relocations may also affect cultural resources.				

Raising Lake Ashtabula would affect various amounts of important wildlife habitat. Woodlands along the river are probably the most valuable wildlife habitat in the basin and are used extensively by deer and other forms of wildlife. White-tailed deer use the woodlands adjacent to the river extensively for winter cover and as a food source. Upland species of birds and mammals provide many recreational opportunities in the area. A 10-foot raise would affect, through temporary inundation, about 22 percent of the woodland in the immediate area and about 12 percent of the woodland vegetation of the entire county. This amount is significant considering that less than 1 percent of the county is actually in the flood pool.

Grassland habitat is of moderate value mostly because of heavy grazing pressure. The grassland is used somewhat by birds and rodents which in turn are prey species for other forms of wildlife. Even though the grassland is of relatively poor quality, it is important because of its interspersion with other habitat types. The value of the grassland could almost be doubled by the elimination of grazing. Presently, most of these areas are grazed shorter than a mowed lawn.

The cropland areas have low wildlife value because during part of the year they consist of plowed fields and have very little ground cover. The cropland has some food value and provides some interspersion habitat for birds and small rodents. Cropland is abundant outside the project area; therefore, the fish and wildlife impacts associated with cropland loss would not be significant.

Wetlands in the project area consist mostly of oxbows and marshes adjacent to the river and Lake Ashtabula. In some cases, grasslands adjacent to the wetlands are heavily grazed, reducing their quality. The oxbows in the area provide good to excellent habitat for aquatic furbearers and bird species.

In most cases, a moderate impact would result if less than 20 percent of a particular habitat type were affected. Mitigation would be required to compensate for the loss of wildlife production. Locating these mitigation lands upstream or downstream or adjacent to other public lands would be desirable because of ease of management and protection of large blocks of habitat.

Enhancement opportunities exist in the area for the preservation or restoration of woodland, wetland, and grassland habitat. These areas would be selected for their value as wildlife habitat. The cost of this enhancement would have to be shared by the local sponsor.

No long-term impacts on fish would be expected from increasing the size of the flood pool. Short-term impact, such as death of some invertebrate populations, would occur. Temporary increases in turbidity and some sedimentation could occur in the flood pool and affect aquatic organisms. Loss of shore vegetation could affect fish spawning.

North Dakota has no federally listed threatened or endangered species of plants. However, the State list of rare plant species includes a sedge and pondweed found adjacent to Lake Ashtabula. The effect on these species is not known.

Raising Baldhill Dam would result in some temporary inundation of riverine environment. The preservation of the riverine environment was identified as a planning objective. Because of the long duration of flooding, especiallly for the larger raises much of the vegetation in the flood pool could be killed. The resulting regrowth would consist of less desirable weedy species such as velvet leaf, pigweed, dock, smartweed, thistle, and ragweed. The species composition and future succession in these areas would depend on the subsequent flooding pattern. Successional processes would be interrupted periodically and set back by each flood. The flood pool would also inundate some State game management areas and refuges. As described above, in many areas, less desirable wildlife habitat would be created by the invasion of weedy species.

Larger, infrequent floods would inundate an additional 900 to 1,500 acres of land beyond that inundated by the design flood pool. The wildlife and aesthetic impacts on this land would depend on the frequency of inundation. Impacts of higher pool levels would be similar except that the extent and magnitude of the impacts would increase. Because the higher pool levels would affect a larger proportion of the habitat, they would be less desirable environmentally.

The higher pool levels would have significant adverse impacts on the riverine environment because of the longer reach of river affected, higher elevation, and longer duration of flooding. The magnitude of the impacts on vegetation would increase drastically with increased pool levels.

Higher pool levels could increase erosion and sedimentation. Depending on the amount, fish, wildlife, vegetation and aesthetics could be adversely affected. Weedy species would probably invade the silted and frequently flooded areas, creating less valuable habitat.

The aesthetic impacts (some of them long-term) of the reservoir raises would be associated with the vegetation, wildlife, and topographic features of the area. The higher pool levels, coupled with a long drawdown period, would destroy existing riparian vegetation along the upper portion of the river. The loss of vegetation would in turn affect wildlife populations. The distinctive valley and coulee landscape would be inundated for periods up to 120 days. A temporary rise in the flood pool and the resulting inundation of the surrounding land could create new opportunities for viewing wildlife.

The Valley City National Fish Hatchery (NFH) is located along the Sheyenne River approximately 3 miles north of Valley City. Its satellite facility, the Baldhill Dam NFH, is immediately below Baldhill Dam. The facilities of the satellite hatchery would be adversely affected. Approximately half of the hatchery's production of walleyes, northern pike, and muskellunge comes from this facility. The fish rearing ponds and other facilities affected would be replaced.

The Baldhill Dam Game Management Area (GMA) is adjacent to Lake Ashtabula in Barnes, Griggs, and Steele Counties. It encompasses 1,419 acres. Although this GMA is managed primarily for white-tailed deer, other upland species, including Hungarian partridge, cottontail rabbits, fox, and waterfowl, also benefit. Adding flood storage would affect a portion of this GMA.

The State also operates waterfowl rest areas on Lake Ashtabula during the fall. Three of these areas are in Barnes and Griggs Counties. They would probably not be seriously affected by a flood pool raise. Water levels in the flood pool would be drawn down by fall; thus, there would be no change from the present management scheme.

At the normal pool elevation of 1266 feet msl, three negative aesthetic impacts must be considered: (1) the height of the dam, (2) the change in vegetation after floods, and (3) the increased gap between the water's edge and shore facilities. These three aesthetic impacts would become greater as the raises increased in height. There is evidence that the increased height of the dam would be considered a negative aesthetic impact in the view of residents and users of Lake Ashtabula. The change in vegetation after a flood would be evident as the flood pool receded and the shoreline was left with dead vegetation and mud. Until new plant communities became established (which would depend on the length of time the vegetation was covered and the variety of new vegetation), the shoreline would not be visually pleasing. Because the local people have expressed an interest in having more trees around the lake, large pool fluctuations would undoubtedly be considered a negative effect. Depending on the extent of the raise and the slope of the bank, some access points might have a considerably wider shore. This effect would be unattractive as well as inconvenient and costly (in terms of providing larger docks, etc.). Effects similar to these impacts on Lake Ashtabula would eb experienced, although to a lesser degree, in downstream rural and urban reaches.

Around Lake Ashtabula, the physical base of the present group of cabins would be affected. Under certain circumstances, these groups might be reestablished farther from the shore in the same areas. However, considering the water quality and negative aesthetic impacts, it is unlikely that these recreationally-oriented communities would show any growth attributable to this raise.

Below Baldhill Dam, development could occur in several communities protected from flooding by the raise. Such growth would depend on overall economic conditions and perceptions of decreased flood risk as well as the actual decrease in risk.

If such growth is predicted, it must be determined whether the growth would occur in the floodplain areas of these protected communities; induced development in the floodplain might be contrary to the intent of Executive Order 11988.

Baldhill Dam provides several benefits, including flood control, water supply, and recreation. The present value of the flood control benefit for the present condition Baldhill Dam is estimated at $105 million (or $3.28 million on an average annual basis). Recreation benefits have been estimated in a similar manner to be $5.4 million (or $167,400 on an average annual basis). Water supply and low-flow benefits also are accrued, such that the total average annual benefits for existing conditions are more than $5 million. These benfits accrue to populations below the dam; recreation and recreationally-based economic benefits are also available to those living around Lake Ashtabula. During the many years the dam has been in existence, any social costs associated with its operation have been fully amortized; that is, any inequities have probably become perceived as part of an implicit "social contract". Any change in the distribution of costs and benefits resulting from a change in the height or operation of the dam could be perceived as a change in the terms of this "social contract" and could be a source of controversy. The proposed raise would benefit downstream users by increasing their level of flood protection while assuring them of the same level of water supply. However, their recreation benefits would suffer (from water quality and aesthetic impairment), as would those of people living on the lake. Most of the social costs would fall, however, solely

on those living above the dam: the disruption caused by acquiring homes and farms, the construction activities associated with the raises of the dam, and the long-term impact ofsomewhat less than attractive surroundings.

With the lake at its normal elevation, access to the water would be over a greater distance, because all permanent structures and facilities would have to be located above the maximum flood pool elevation. After a flood requiring a lengthy drawdown period, this expanse could be covered by mud or new weedy growth. Because the lake has already been criticized for problems involving its declining water quality, it is possible that lake-related recreation might suffer even further under these conditions.

Noise and other construction-related impacts would occur at the damsite, on roads used for construction routes, and along the lake's shoreline as cabins are acquired. The extent of these disruptions would depend directly on the height of the raise.

Existing bridges at Ashtabula Crossing, Keyes Crossing, and Wesley Acres (County Road 9) would have to be elevated or redesigned to allow continued use during floods for the larger raises considered. These changes would affect the aesthetic character of the lake when the pool is at its normal elevation. The Great Northern Railroad crossing may also need to be improved for the larger raises. Local governments have been financially strained by the maintenance of gravel roads in the existing recreation areas. Lengthy, sporadic inundation of these roads would make more maintenance necessary and more expensive if access to the fluctuating shoreline were to be continued.

All of the raises would involve the acquisition of properties. The 5-foot raise would require the acquisition of 6 farmsteads and residences.

97 cabins, 2 church camps, and 2 other properties. The 25-foot raise would affect 21 farmsteads and residences, 190 cabins, and 7 other properties. The two church camps are Wesley Acres Camp on Baldhill Creek and Cooperstown Bible Camp on the Sheyenne River just upstream of Lake Ashtabula. Both camps are at least partially affectd by the 5-foot raise; however, better topographic information in the camp area is needed to determine just how much and which parts of the camps would have to be acquired in either fee title or in easement. Raises of 10 feet or more would require the full acquisition of both camps.

Public Law 91-646, the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, was enacted to provide for the uniform and equitable treatment of persons displaced from there homes, businesses, or farms by Federal and federally assisted programs. Relocation of permanent residents generally requires that comparable decent, safe, and sanitary dwellings be available. Determination of availability has not yet been made. Seasonal residents, businesses, and farms may be eligible for advisory services and payment for actual reasonable moving expenses.

A probably response of relocated owners would be to sell their present property and structures and attempt to purchase land farther back from the shore. If they are able to buy this land, or if their present land extends far enough beyond the "take" elevation, they can easily purchase their previous structures for salvage value and have them placed on the more distant property. If they were able to do this, they would probably not suffer economic damages, and social values such as community cohesion would be maintained (for example, a given group of neighbors will continue to live in the same pattern and proximity). However, they would be living farther from the water's edge for most of the year, which could lower their property values. If they were unable to move directly back from the shore, they could move to another area of the lake or away from the lake entirely. In either case, community cohesion would be temporarily damaged, and recreational values would be lost for those moving away from the lake.

One of the inevitable results of any raise of Lake Ashtabula would be a dislocation or reduction in the amount of farmland. These changes could be a direct result of farmland being purchased because of the higher flood elevation or for wildlife mitigation, or they could be an indirect result of the land being voluntarily sold to relocating residents, businesses, and recreation-providing organizations. These effects would also be experienced over a larger reach of the Sheyenne River and Baldhill Creek because the higher elevation would extent along their paths into farmland presently unaffected.

All of the raises would benefit 790 farmsteads and residences, 70 businesses, and 2 public facilities. These properties are in Valley City and Lisbon. However, additional properties would benefit in the rural reaches from Baldhill Dam to Kindred. Properties along the Sheyenne River downstream of Kindred would receive additional benefits for the second peak.

On the basis of an estimate of three persons per residence and the number of residences that would need to be relocated for each raise, 15 to 63 persons would be relocated for the 5- to 25-foot raises. However, this alternative would benefit 2,350 persons along the Sheyenne River from Baldhill Dam to Kindred.

Approximately 2,700 acres of land would be acquired either in fee title or through flowage easements for implementation of the 5-foot raise. Included in the 2,700 acres are about 670 acres over which flowage easements are presently owned. Greater acreages would be All of these lands required for construction include fish and wildlife mitigation lands and are lands beyond those already in Government ownership. The lands along the Sheyenne River from Baldhill Dam to Kindred that would benefit from reduction of the second peak are 23,250 acres of cropland and 100 acres of urban land.

APPENDIX M

PLAN FORMULATION

GENERAL REEVALUATION
AND
ENVIRONMENTAL IMPACT STATEMENT

SHEYENNE RIVER, NORTH DAKOTA

AUGUST 1982

APPENDIX M

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APPENDIX M

PLAN FORMULATION

INTRODUCTION

Plan formulation consists of several major steps: problem identification, development and evaluation of alternatives, and plan selection and recommendations. The Kindred Lake project was authorized on the basis of studies done in the 1960's, and the Federal criteria for evaluating water resource projects have changed significantly since then. Therefore, a major reevaluation of the project was needed. The planning process was designed to objectively reevaluate problems and needs in the basin and assess the relative merits of the many alternatives using previously gathered information as much as possible. The validity, applicability and credibility of this information had to be considered as the information was used. This appendix describes the pertinent steps in the plan formulation process for this study.

AUTHORIZED PROJECT

The plan authorized by the Flood Control Act of 1970 consists of a multiple-purpose reservoir for flood control, water quality control, recreation, and fish and wildlife on the Sheyenne River near Kindred; a revised operating plan for Baldhill Dam; and appropriate floodplain management measures at Lisbon, Valley City, and West Fargo. The Kindred Dam would be at river mile 76.2 on the Sheyenne River, approximately 5 valley miles above Kindred. It would control runoff from about 98 percent of the effective drainage area above West Fargo and about 62 percent of the total effective drainage area. The reservoir would store 412,000 acre-feet at the design pool (elevation 1017.0). Of this amount, 22,000 acre-feet would be reserved for sedimentation over the first 100 years of project life; 60,000 acre-feet would be provided as multiple-use storage for water quality control, recreation, and fish and wildlife; and 330,000 acre-feet would be reserved exclusively for flood control. The 11,000 acre-feet of water quality storage would also provide for water supply to permit an additional winter drawdown of Lake Ashtabula for increased flood control. The water supply capability of Lake Ashtabula would not be reduced through modification of the operating

plan until Kindred Lake was constructed and capable of fully compensating for the reduced flow supplements from Lake Ashtabula. The normal water quality pool level of Kindred Lake, elevation 984.5, would provide about 5,500 acres of water surface for recreation. A surcharge storage for the spillway design flood would amount to 74,000 acre-feet which would be contained in the 4½ feet above elevation 1017.0. The dam, spillway, outlet works, relocations, and other features are described in the following paragraphs; pertinent data are presented in table M-1. Features of the authorized project are shown on plate M-1.

Table M-1 - Summary of pertinent data, authorized Kindred Lake project(1)

Item	Amount
Storage capacity (acre-feet)	
Flood control	330,000
Multiple use	60,000
Water quality	(60,000)
Recreation and fish and wildlife	(60,000) (2)
Water supply	(11,000) (3)
Sedimentation	22,000
Total	412,000
Dam	
Type	Earth fill
Maximum height	95 feet
Length	3,400 feet
(Includes gated concrete spillway and multiple-level low-flow outlet structure.)	
Elevations (feet above mean sea level)	
Top of dam	1026.5
Spillway design pool	1021.5
Flood control pool	1017.0
Multiple-use storage pool	984.5
Lowest level outlet	958.0
Impacts	
Relocations	
4-H camp	1
Cemeteries	2
Churches	3
Acquisitions	
Farmsteads	52
Land	20,000 acres

(1) As presented in the authorizing document.
(2) Water quality pool provides 5,500 acres for general recreation and a warmwater fishery.
(3) Water quality pool provides 11,000 acre-feet for water supply transferred from Lake Ashtabula to permit increased upstream flood control.

The dam would be a rolled earth-fill structure, 95.5 feet high with a crest length of 3,400 feet and a top elevation of 1026.5 feet msl (above mean sea level). The embankment would consist of an impervious core supported by a shell of random fill with 1 on 3 slopes both upstream and downstream. The spillway would consist of a concrete ogee crest and chute equipped with two 48- by 29-foot tainter gates at the spillway crest for passage of floods exceeding the reservoir design flood. The outlet works would consist of two 6-foot-wide by 10-foot-high, low-level flood control outlet conduits incorporated into the spillway gate piers and a multiple-level outlet structure for water quality control combined with the spillway piers. Reservoir development would involve relocation of Barrie Cemetery (85 graves), Owego Cemetery (85 graves), State Highway 18, and electric and telephone lines; removal of eight bridges; and tying down of two bridges.

The reservoir would offer a variety of activities including boating, water-skiing, fishing, swimming, camping, picnicking, and sightseeing. About 2,500 acres of land would be set aside exclusively for general recreation and fishing at five public use sites--one overlook, one downstream bank fishing area, and three large recreation areas along the margin of the reservoir. The proposed mitigation features include 9,500 acres of land for wildlife management to offset the loss of existing wildlife habitat within the permanent pool and replacement of the Mirror Pools fish-rearing pond complex.

The capacity of the reservoir was based on the maximum the topography would allow within practical limits. All storage was allocated to flood control except for the minimum required for sediment accumulation and water quality storage. Of the top 9.5 feet of storage, 4.5 feet would be for surcharge storage of the spillway design flood and 5.0 feet would be for freeboard above the spillway design flood water surface elevation. When the pool reached elevation 1021.5, the spillway gates would be opened completely. When the reservoir was at water quality pool elevation 984.5 at the beginning of a flood, outflow would be regulated at about 700 cfs (cubic feet per second) or less to minimize downstream flooding, particularly at West Fargo and on the Red River. With a release rate averaging about 700 cfs for 24 days and then increasing to about 2,000 cfs, the reservoir

would store up to about a 200-year frequency flood on the basis of the inflow hydrograph developed from the volume-frequency curves and adjusted for modified operation of Baldhill Dam. When the reservoir design pool elevation of 1017.0 was reached, outflow would be increased to 2,000 cfs or an outflow based on the induced surcharge envelope curve adopted for Kindred Lake, whichever is greater. After peak inflow, outflow would equal inflow. Flood storage would be evacuated from the reservoir at about 2,000 cfs or less so as not to cause flooding downstream or add to peak flows on the Red River. Basically, the operation of the reservoir for water quality control would involve mixing and flushing of irrigation return flows with better quality spring runoff and the resultant dilution of return flows in the 82,000-acre-foot conservation pool.

The plan would provide only limited flood damage reduction at Valley City and Lisbon. Thus, a serious threat from large floods would remain at these communities. Accordingly, sound floodplain management measures, including zoning to prevent unwise future development of the 100-year floodplain, are required to reduce future damages and serve as an integral element of the proposed plan. High stages on the Red and Maple Rivers could produce significant residual damages at West Fargo even with full control of Sheyenne River flows unless future construction is regulated in the low area north of U.S. Highway 10.

Kindred Lake would reduce flood stages and was projected to alleviate anticipated water quality problems on the Red River. Thus, it was considered an integral element of a basinwide water resource development and management plan for the Red River.

PROBLEM IDENTIFICATION

GENERAL

The problem identification process addressed public and agency concerns and analyzed the water resource purposes considered for the basin. The water resource problems and needs presented here include flooding, water supply, water quality, recreation, fish and wildlife, hydropower, and cultural resources.

PUBLIC CONCERNS

Public concerns were expressed through interviews with agency, community, and organization representatives as well as public workshops, citizens committee meetings, and individual citizen input. Public concerns were also established through review of past reports.

In October 1968, the St. Paul District completed a feasibility study for the Sheyenne River. The report brought out that frequently recurring floods, particularly along the lower 70-mile reach from Kindred to the mouth, seriously damage existing urban developments, agricultural areas, and transportation facilities. In addition, Sheyenne River high flows aggravate the very damaging floods on the Red River. The report also concluded that, unless measures were undertaken, the expected continued development of the floodplain areas at Valley City, Lisbon, and the rapidly growing city of West Fargo would lead to worse flood damages. The report indicated a significant need for water quality improvement in the Red River basin to offset adverse mineral quality deterioration caused by irrigation return flows from the authorized Garrison Diversion Unit. It also indicated that several existing water-based recreation areas were readily accessible to residents of the upper Sheyenne River basin. However, available water-based outdoor recreation developments are extremely limited and inadequate in the lakeless region of the lower Sheyenne River basin and surrounding areas. Lakes and reservoir developments in both Minnesota and North Dakota are generally too far away for frequent visits by residents of the lower Sheyenne River basin, including the Fargo-Moorhead area. A comprehensive outdoor recreation planning report prepared by the North Dakota State Recreation Agency in 1966 disclosed large latent present and future demands for additional water-based recreation opportunities, including fishing, in the lower basin.

In 1966, two reconnaissance investigations were made--one for Valley City and one for Lisbon. The reports pointed out the flood problems at both communities but could not show economic justification for any Federal assistance.

In 1947, the Corps completed a survey report on the Red River basin for flood control and other purposes. This report recommended construction of channel improvements on the lower Sheyenne, Maple, and Rush Rivers to address the flooding problems in this confluence area. However, because of opposition from local interests, the recommended channel enlargements on the Maple and Sheyenne Rivers have not been constructed.

In 1942, a survey report was completed that addressed both flood control and water supply along the Sheyenne River. This report resulted in the construction of the dual-purpose Baldhill Dam as a solution.

The current studies have been coordinated extensively with the public and other agencies. (A list of these Federal, State, and international agencies can be found in table A-4 of Appendix A.) A key concern of the majority of the agencies was that the solutions to flooding problems consider all possible alternatives and, in particular, that the Corps' Phase I GDM (General Design Memorandum) studies objectively analyze all alternatives before recommending implementation of any one alternative. Further, some concern was expressed about the potential effects of a permanent pool at the proposed Kindred Dam site on groundwater levels in adjacent areas.

Problem identification was also assisted by public concerns expressed through the Lower Sheyenne River Citizens Committee. The committee was made up of representatives of area groups, organizations, and communities and has been instrumental in expressing the concerns of area residents. Meetings were held almost monthly over most of the study period and at different locations throughout the study area. At the meetings, great concern was expressed about the more frequent flooding between Baldhill Dam and the mouth. Concern was also expressed that people who are not being flooded should not have to bear the adverse impacts of solving the flood problems, especially through the loss of land.

In addition to these meetings, which were open to the public and at which public participation was encouraged, individual citizens were invited to express their concerns at public workshops. On 27 June 1977, a public workshop held to discuss the water-related problems and needs of the basin

and identify alternatives to address these problems and needs was attended by more than 150 people. They divided into small groups and identified problems and possible solutions in three categories: (1) flooding; (2) recreation, wildlife, and historical; and (3) water quality, quantity, and other. Those attending the workshop also ranked each problem by priority--high, medium, or low. The results of this workshop are summarized in table M-2.

FLOOD PROBLEMS

The 1882 flood is the earliest flood for which any record or definite information exists. At Valley City, the principal damage center of the basin at that time, high-water data considered reliable indicated that a large portion of the residential section and all of the business section were inundated. At Lisbon, the area subject to flooding was confined to a narrow strip along the riverbank and damage was negligible. Above Kindred, a low section of the left bank was overtopped, causing a considerable portion of the town to be inundated to a depth of about 6 inches. Downstream of Kindred, over 100,000 acres were inundated by floodwaters from the Sheyenne, Red, Wild Rice, and Maple Rivers.

The 1965 flood caused only minor damage at Valley City and Lisbon. However, backwater from ice caused a record stage at Kindred. Backwater from the Maple River caused near record stages at West Fargo.

The 1966 flood could have caused extensive damage at Valley City; however, quickly constructed sandbag levees prevented damage to most residential and commercial developments. At Lisbon, over 100 basements were flooded by sewer backup, while high flows damaged a sewer lift station and the city dam. Because of the early flood forecasts and emergency levees constructed at the damage centers during the 1965 flood, much damage was prevented. At West Fargo, additional sandbagging and sewer pumping minimized flood damages that could have been caused by backwater from the Maple River. Overflows from the Sheyenne, Maple, and Rush Rivers combined and flooded more than 40,000 acres of these confluence lands.

Table M-2 - Results of the 27 June 1977 citizens input workshop - identified problems and needs

IDENTIFIED PROBLEMS AND NEEDS: FLOODING

Problem or Need	Priority
1. Flood Plain Development, Residential Commercial	H
2. Uncontrolled Stream Drainage	H
3. Water Release Problems from Baldhill Dam	H
4. Overall Drainage Problems in the Harwood Area	H
5. Need for a Hydrology Study of Drainage Areas	H
6. Flooding in Red River Valley & Basin	H
7. Farmland Drainage, How to Control It	H
8. Overflowing of Cass County Drains No. 45, 21 & 13	H
9. West Fargo, Commercial & Residential Flooding	M
10. Agriculture Flooding-- Kindred to Red	M
11. Maple River Contribution to Flooding	M
12. Erosion, Agricultural	M
13. Rush River- Contribution to flooding	M
14. Erosion, Stream Bank, West Fargo	M
15. Erosion, Road and Bridge	M
16. Harwood and Surrounding Area Flood Problems, Residential, Agriculture, Road and R.R.	M
17. Argusville Drain No. 13 Overflowing	M
18. Need for Hydrology Study of Entire Sheyenne Basin	M
19. Need for Hydrology Study of Road System	M
20. Urban Flooding Of Kindred	M
21. Urban Flooding of Horace	M
22. Urban Flooding of Lisbon	M
23. Urban Flooding of Valley City	M
24. Urban Flooding of Fort Ransom	M
25. Urban Flooding of Argusville	M
26. Township Flooding of Norman, Cass	M
27. Township Flooding of Freeman, Richland	M
28. Development in Floodplain Reducing Stream Flow Capacity	M
29. Overland Flooding in Sheyenne Basin	M
30. Problem with High Water Table in Richland and Ransom Counties	M
31. Need to Determine the Effect of Urbanization on Sheyenne Flooding	M
32. How Can We hold Water Back in the Headwaters to Recharge Ground Water	M
33. Protecting Development in Flood Plain	M
34. Culvert Opening too Large in Roads and Drains	M
35. High Water in Sheyenne Renders Drainage System Ineffective and Allows Backflows	M
36. Pollution of Wells	L
37. Urban Flooding of Fargo	L
38. Urban Flooding of Kathryn	L
39. Township Flooding of Helendale	L
40. Flood Damages to Wildlife Habitat	L
41. Determine Feasibility of Increasing Holding Capacity of Baldhill Dam	L
42. Social Impacts (caused by flooding)	L
43. Recreational Losses	L
44. Health Problems (insect, well contamination)	L
45. Impact of Future Economic (property values, rural, urban) and Urban Development	L

IDENTIFIED PROBLEMS AND NEEDS: WATER QUALITY, QUANTITY AND OTHER

Problem or Need	Priority
1. Drainage Contributing to Degradation of Water Quality in Lower Sheyenne	H
2. Need to Stabilize Flow	H
3. Need for Improved Sewage Treatment Systems	H
4. Up-Stream Polluters Have no Concern for Downstream Neighbors	H
5. Need to Determine Causes for Poor Water Quality	H
6. Dead Animals Dumped into River	H
7. Feedlot Runoff into Sheyenne River	H
8. Fort Ransom Dumping Sewage into River	H
9. Increased Residential Building in Rural Areas adding to Lowering Water Quality	H
10. Need to Preserve Natural Purification Areas in the Sheyenne Basin	H
11. Need to Coordinate Garrison and Sheyenne River Planning	H
12. High Water Tables Cause Problems	H
13. Need to Retain Surface Water Supplies	H
14. Declining Underground Water Supplies	H
15. Bad Effects on Fish from Dissolved Solids in Lake Ashtabula	H
16. Inadequate Urban Water Supply	M
A. Fargo	M
B. Moorhead	M
C. West Fargo	M
17. Need to Improve Water Quality in Lake Ashtabula	M
18. Need to Raise Water Quality Standards for Streams	M
19. Poor Water Quality in Lower Sheyenne River and Tributaries	M
20. Excessive Use of Fertilizers	M
21. Problem in Meeting Canada's Quality Standards	M
22. Limit Economic Growth to Amount of Available Water	M
23. 4-H Camp Dumping Sewage into River	M
24. Inadequate Rural Water Supplies	M
25. Aquifer Contamination from Irrigation Runoff	M
26. Poor Water Quality Adversely Affects Soil and Livestock	M

IDENTIFIED PROBLEMS AND NEEDS: RECREATION, WILDLIFE, HISTORICAL

Problem or Need	Priority
1. Preservation of Sandhill Environment	H
2. Wildlife Habitat Preservation	H
3. Preservation of Prairie Chicken Habitat	H
4. Preservation of Duck Habitat	H
5. Preserve Woodland of Sheyenne Basin	H
6. Need to Reduce Conflicts Between Recreation and Multiple Purpose Uses	H
7. Private Landowners are Liable for Accidents on Private Land and are not Compensated for Recreational Use	H
8. Need to Determine Value of Small Springs coming into Sheyenne	H
9. Need to Determine Economic Value of Recreation to Area	H
10. Need to Maintain Unique Areas	H
11. Need to Improve Trapping	H
12. Need for Land Based Recreation in Sandhills	M
13. Preserve Scenic Values of Sheyenne Basin	M
14. Wildlife Habitat Preservation (of deer)	M
15. Need for Improved Forestry Management	M
16. Need for Preservation at Little Yellowstone Fort Ransom Area	M
17. Study, Identify and Preserve Archeological and Historical Resources	h.
18. Develop Suitable Areas for Off-Road Recreation Vehicles in Sandhills Area	M
19. Obstructions in River Prevent Canoeing	M
20. Need to Develop Hiking Trails	M
21. Need to Determine Value of Natural Vegetation in Sheyenne Basin	M
22. Need for Better Recreational Planning in the Area	M
23. Need to Improve Hunting	M
24. Need to Improve Fishing	M
25. Need to Develop Water Based Recreation-Sheyenne Basin	L
26. Public Acquisition & Preservation of Selected Lands for Recreational Use	L
27. Better Identification of Public Areas with Signs	L
28. Need for More Camping Facilities	L
29. Need to Develop Fort Ransom Park	L
30. Preserve Mirror Pool Area	L
31. Need to Determine Possible Effect of North Country Trail	L

The 1969 flood caused a major threat throughout the basin, and Baldhill Dam played a major role in reducing the magnitude of the flood. Because of early flood forecasting, Lake Ashtabula was drawn down twice the normal amount before the area upstream started to run off. However, the high runoff could not be contained, and releases exceeding channel capacity were required. The flood downstream of Valley City had two flood peaks. In some cases, the second peak, which occurred 1 to 2 weeks later than the first, was higher. The second peak was reduced by operation of Baldhill Dam. Emergency works at Valley City and Lisbon in combination with the operation of Baldhill Dam were effective in preventing damages at these communities. At Horace, flood levels remained at or near peak stage for nearly 4 weeks. The unusual duration caused seepage into the sanitary sewage system, and raw sewage had to be pumped into a county drain. The first peak at West Fargo was aggravated by backwater from the Red and Maple Rivers. The Sheyenne River remained at or near crest for almost 4 weeks at West Fargo, also causing basement flooding of several homes. Floodwaters in the vicinity of West Fargo extended for 5 to 7 miles across the valley as a result of combined overflows from the Sheyenne, Wild Rice, Maple, Rush, and Red Rivers.

The 1975 flood reached record levels at West Fargo, with the Maple River again playing a major role through backwater effects. In spite of this record stage, major damages were prevented by the emergency works constructed at West Fargo.

The 1979 flood was similar to the 1969 flood along the Sheyenne River. Again, Baldhill Dam played a major role in reducing the second peak. In conjunction with the emergency works at Valley City, Lisbon and West Fargo, the dam prevented major flood damages. At Valley City and Lisbon, emergency clay and sandbag levees prevented damages to most residential and commercial development. Overflows downstream of Kindred had been reduced by the construction and/or raising of agricultural levees which confined flows and increased stages. At West Fargo, emergency clay and sandbag levees prevented damages to most residential and commercial development. However, flood levels again remained at or near peak stage for several weeks, causing seepage and basement flooding.

Backwater from the Maple and Red Rivers combined with the Sheyenne River flows north of West Fargo to spread floodwaters for several miles across the valley.

Throughout most of the basin, emergency flood protection levees have been constructed since at least 1965. These levees have been built with considerable variations in adequacy, have demonstrated various degrees of effectiveness in preventing flood damages, and have been maintained at varying levels of readiness for future floods. The potential of these existing levees to provide future flood protection must be assessed to develop flood damage reduction plans and to determine the benefits creditable to a plan.

The existing levees throughout the basin have generally been constructed immediately before a major flood with poor quality control for the construction. Sandbags have been used in many portions of the levees, and compaction of imperious material in other parts of the levees either has been poor or has not been accomplished at all.

Sections of some levees have been removed and would have to be replaced for a future flood. Sections of some levees have extremely steep side slopes and have suffered from streambank erosion in most instances. The levees are on private property, with no formal agreements between the property owners and the communities for access to and/or maintenance of the levees.

Table M-2A provides a general assessment of the existing levees throughout the basin and summarizes whether any credit has been given to the levees as a reliable means of protection from future floods.

Table M-2A - Status of existing levees along the Sheyenne River, North Dakota

Community or reach of Sheyenne River	River mile	Status of existing levees	Credit given toward effectiveness in future floods
Valley City	252 to 257	Upgraded for 1979 flood; several large sections of sandbags only; several sections removed at bridges; generally built at edge of riverbank with very steep slopes.	None: the open sections and the sandbag portions render the system incomplete.
Lisbon	160 to 162	Upgraded for 1979 floods; most sections have very steep slopes and built right on the edge of the riverbank.	None: steep side slopes, closeness to edge of riverbank and lack of adequate sectional area render system unreliable.
Horace	40 to 42	Upgraded for 1975 flood; several sections are built on the edge of the riverbank and have been experiencing bank erosion.	None: the closeness of the levee to the riverbank poses significant potential for failure.
West Fargo/ Riverside	24 to 30	Upgraded for 1979 flood; many sections have sandbagged cores; bank stability has been a continual problem as some sections have experienced sliding problems: most of the levee is built on the very edge of the riverbank; several areas rely on sandbag or earthern closures during a flood.	None: the material in the levee is not reliable (a major break occurred during the 1979 flood) and many levee sections are accessible only by foot during floods.
Reach 2	215 to 271	Some individual levees at farmsteads and residences, including a partial levee at the National Fish Hatchery.	None: Very few levees and little effect on damages.
Reach 3	126 to 215	None known.	None.
Reach 4	76 to 126	None known.	None.

Table M-2A - Status of existing levees along the Sheyenne River, North Dakota (continued)

Community or reach of Sheyenne River	River mile	Status of existing levees	Credit given toward effectiveness in future floods
Reach 5A	40 to 76	More or less continuous private agricultural levees of some sort parallel the river; built to different levels and not reliable during floods. Some are overtopped each flood; however, not always the same ones.	None: during a flood, some sections of levee in this reach are overtopped and/or fail.
Reach 5B	30 to 40	More less continuous private levees of some sort through the agricultural areas and the subdivisions. Many sections of levee in subdivisions are built very close to riverbanks and have experienced erosion and stability problems.	None: the erosion and bank stability problems as well as lack of maintenance creates many areas of weakness.
Reach 5C	20 to 30	Some agricultural levees paralleling the river plus some sandbagging at homes and residences.	None: sandbags have been removed; upstream breakouts have circumvented levees.
Reach 5D (includes Harwood and Rivertree Park)	10 to 20	Some agricultural levees plus some levees at residential areas. Most are generally very close to riverbank with slope stability a frequent problem.	None: major flooding occurs in agricultural areas in spite of the existing levees. Lack of stability renders levees at residential areas unreliable.
Reach 5E (includes Brooktree Park)	0 to 10	Some levees at residential area; few agricultural levees	None: major flooding occurs throughout the agricultural areas. Limited protection provided to residences.

WATER SUPPLY

After the severe drought of the 1930's, the Committee on Commerce of the United States Senate asked the Corps of Engineers to review the water resource problems in the Red River basin. The studies found a water shortage resulting in part from lowered groundwater levels. The search for more groundwater led to tapping of deep subterranean supplies that were difficult to treat or injurious to health. Municipalities and industries also needed a water supply for proper treatment and dilution of sewage water. The studies concluded that the water shortage in the Sheyenne and Red River basins could be alleviated by construction of Baldhill Dam for the dual purposes of flood control and low-flow augmentation. The benefits of the project were estimated as flood control - 8 percent, municipal water supply - 38 percent, municipal pollution abatement - 23 percent, and rural water supply - 31 percent. Baldhill Dam was built with the requirement that the local sponsor:

1. Construct, operate, and maintain the Sheyenne River diversion dam and ditch improvements which allow water from the Sheyenne River to enter the Red River upstream of the Fargo municipal water supply intake system.

2. Maintain the river channel below Baldhill Dam to ensure the satisfactory flow of water released from storage.

3. Establish and enforce suitable regulations to prevent pollution of the Sheyenne River.

On the basis of the money contributed and the population of the communities involved, the stored water was allocated in the following proportions: 52 percent for Fargo; 29 percent for Grand Forks; 9.7 percent for Valley City; 2.6 percent for Lisbon; 1.4 percent for West Fargo; 4.0 percent for American Crystal Sugar Company in Moorhead; and 1.3 percent for Union Stockyards, Great Northern Railroad, Northern Pacific Railroad, Soo Line Railroad, and Northern States Power Company.

Valley City obtains its water from wells drilled into the water-bearing gravel deposits in the Sheyenne River valley. During drought years, the water in the wells fell to a dangerously low level. A diversion pipe was constructed about 1.2 miles upstream of the city to divert Sheyenne River flows into a gravel pit which was an outcrop of the same formation tapped by the municipal wells. The Sheyenne River water is chlorinated as it enters the pipe and water delivery is gravity operated by means of the head maintained by the dam. Another dam was constructed across the Sheyenne River about 10 miles upstream of Valley City to provide additonal storage which can be released to the lower reservoir as desired.

Lisbon formerly obtained its water from three artesian wells ranging from 730 to 910 feet deep. In 1956, the city switched to shallow wells, approximately 50 feet deep which tap the Sheyenne River aquifer. Presently, Lisbon has two wells, and the water is treated for calcium and iron before it is pumped into the city mains.

The city of West Fargo has three wells ranging in depth from 200 to 240 feet. The wells tap the West Fargo aquifer. The water is chlorinated before being pumped into the city system.

Fargo has had trouble maintaining an adequate water supply. Before 1910, it depended on wells less than 200 feet deep for its potable water and on the Red River for its fire protection. In 1910, the wells began to fail and the search began for additional underground supply. In the meantime, the Red River was used as the chief source of supply and is still being used today. Since building a diversion from the Sheyenne River in 1972, Fargo has been able to use water stored in Lake Ashtabula. As mentioned earlier, Fargo was allocated 52 percent of the water from Lake Ashtabula. In September 1976, during a short drought period, Fargo had to restrict water use to its residents. At this time, Fargo started using water from Lake Ashtabula and did so for approximately 8 months. During this period there was essentially no flow in the Red River, and the only flow to Fargo's water intakes was that diverted from the Sheyenne

River. Fargo has constructed four channel dams on the Red River, furnishing some storage for water supply. One is located north of St. Johns Hospital and forms the pumping pool for the city's water plant. The others are located in South Fargo, just south of Hickson, and just north of Christine. Table M-3 shows the anticipated water demands on the Sheyenne River for 1980 and 2030 for Valley City, West Fargo, and Fargo. These cities depend entirely or in part on the Sheyenne River for water supply as discussed above.

Table M-3 - Anticipated water demands for 1980 and 2030 at major water use control points

	Valley City				West Fargo				Fargo			
	1980		2030		1980		2030		1980		2030	
Month	Mgd (1)	Cfs (2)	Mgd	Cfs	Mgd	Cfs	Mgd	Cfs	Mgd	Cfs	Mgd	Cfs
October	1.3	2	1.3	2	0.8	2	1.9	3	8.6	14	15.8	25
November	1.3	2	1.3	2	0.7	1	2.0	3	8.8	14	14.3	22
December	1.3	2	1.3	2	0.8	2	1.7	3	8.4	13	13.8	22
January	1.3	2	1.3	2	0.7	1	1.4	2	7.9	12	13.8	22
February	1.3	2	1.3	2	0.8	2	1.8	3	8.9	14	17.5	27
March	1.3	2	1.3	2	0.7	1	1.9	3	8.2	13	15.8	25
April	1.3	2	1.3	2	1.0	2	2.2	4	10.8	17	16.3	25
May	1.9	3	1.9	3	1.5	2	2.6	4	15.0	23	19.8	31
June	1.9	3	1.9	3	0.9	2	2.2	4	10.7	17	18.4	28
July	3.9	6	4.5	7	1.4	2	2.4	4	16.0	25	21.7	34
August	3.2	5	3.9	6	1.0	2	2.1	4	11.2	18	17.8	28
September	1.9	3	2.6	4	0.8	2	2.0	3	9.3	15	16.3	25

(1) Million gallons per day.
(2) Cubic feet per second.
(3) Summarized from E.A. Hickok Report, March 1982.

The Bureau of Reclamation's Garrison Diversion Unit is a multiple-purpose water resource project designed to divert Missouri River water into central and eastern North Dakota. The water would be used to irrigate agricultural land, provide municipal and industrial water supplies, furnish recreational opportunities, and provide for the development of fish and wildlife areas. The project would irrigate 250,000 acres of land through the annual transfer of 510,000 acre-feet of water from the Missouri River. The project has been the subject of numerous studies and has been challenged in court. Numerous issues remain to be resolved including those related to potential impacts of the project on Canada and the wildlife plan and mitigation. The project is stalled as a result of a Federal court order. The action is being appealed by the Department of the Interior and State of North Dakota. Discussions are also taking place with Canada in an effort to resolve Canadian concerns.

Most of the basin is underlain by one or more aquifers. These aquifers can be divided into two major categories: major and minor. Major aquifers are traceable over large areas, produce moderate to large yields, and are frequently used or have the potential for significant development. Minor aquifers are used in the absence of major ones. Though individual minor aquifers are numerous, their extent and productivity are limited. As with the major aquifers, the chemical quality and depth are variable, and the aquifers are of glacial and bedrock origin.

Unlike the surficial drainage system, which defines the Sheyenne River basin perimeter, the groundwater system does not necessarily conform to this definition. The small aquifers (like the Courtenay and Central Eddy) tend to be entirely within the basin. Larger aquifers (like the Spiritwood and New Rockford) are found not only within the basin but also within the Missouri River basin and other Red River subbasins.

With local exceptions in the Fargo-Moorhead and Kindred areas, most areas of the basin have adequate groundwater for the immediate future. However, any significant change in recharge, resulting from a prolonged drought, extensive pothole drainage, or any significant increase in demand (for industrial, municipal, and agricultural development), could significantly alter this outlook. Because the basin is in a predominantly agricultural area, it is vulnerable to droughts which, in turn, increase groundwater demand for irrigation, as happened during the 1976 drought.

The preliminary analysis of the major users of Sheyenne River water for both existing and anticipated future demands does not indicate any serious shortages in the foreseeable future. Evaluations used the recurrence of the precipitation and runoff characteristics of the 1930's drought and the current and projected water use characteristics including the water demands listed in table M-3 to estimate potential shortages. The drought of the 1930's is estimated to have been a very infrequent drought, more severe than is normally used for water supply planning purposes. With no serious shortages indicated during a recurrence of the 1930's drought, no major water supply needs are indicated in the foreseeable future.

WATER QUALITY

The bacteriological and chemical characteristics of the lower Sheyenne River have been documented over the past several years. In general, bacterial levels indicate poor water quality. The agricultural and mixed agricultural-municipal areas were identified as being responsible for the highest incidence of fecal coliform contamination. The fecal coliform content of the water exceeds State and Federal standards for recreational waters. The high bacterial counts are due to agricultural and municipal effluent. Releases from Baldhill Dam of large or moderate proportions tend to dilute this pollution; however, low releases do little to enhance water quality.

Chemical constituents such as nutrients, sulfates, total dissolved and suspended solids, and chemical oxygen demand can be excessive and reduce the desirability of the water for recreational and consumptive uses. The pollutant load of the river increases significantly during spring runoff. Agricultural and municipal operations influence the chemical characteristics of the river. The water quality of the river affects its fishery, recreational and scenic value, and personal health of the users.

RECREATION

A number of land-based recreation areas, including city, county and State parks with associated facilities, exist throughout the basin. Also, several existing water-based recreation areas are readily accessible to people living in the portion of the basin from Valley City upstream: Lake Ashtabula, Jamestown Reservoir, Pipestem Reservoir, and several smaller impoundments in adjacent river basins. If the Garrison Diversion Unit proceeds and includes restoration of Devils Lake, the recreational value of the Devils Lake area should be enhanced. However, available water-based outdoor recreation development is extremely limited in the lakeless region of the lower basin and surrounding areas. The Fargo-Moorhead metropolitan area is about 50 miles from Detroit Lakes, Minnesota; 90 miles from Lake Jim; 160 miles from Devils Lake; and 150 miles from South Dakota Lakes.

Although boating, canoeing, and camping are highly popular or rapidly growing in popularity, opportunities are limited and inadequate in the lower basin. The need exists for water acres, access to existing resources, preservation of and upgrading of existing resources, and acquisition and development along these resources. With the preservation, upgrading, acquisition, and development of existng and new water resources in the area, the increasing needs for fish and wildlife habitat could be met. The need for hiking, cross-country skiing, and horseback riding trails is increasing in conjunction with the above recreation areas.

FISH AND WILDLIFE

The Sheyenne River basin has relatively limited wooded areas, brush, and other desirable habitat to support wildlife, except in the river valley and coulee areas, particularly in the valley reach between Kindred and Valley City. The river valley and adjacent uplands provide valuable wildlife habitat for both common and rare species in North Dakota. These species include deer, prairie chicken, waterfowl, squirrel, barred owl, wild turkey, upland plover, and marbled godwit. The latter two are found mostly in the higher prairies of the Sheyenne National Grasslands.

Although few natural lakes exist in the basin, the Sheyenne River and Lake Ashtabula provide both warmwater and stream fishery values. However, the fishing is somewhat degraded or restricted because of the water quality and associated effects.

About 1,500 acres of land have been tentatively identified as areas having natural significance either because of the size or type of vegetation present or the wildlife species they support. In the 5 counties that make up the lower basin, 55 sightings of rare or unique plants have occurred. The preservation of natural areas and valuable fish and wildlife habitat is an identified need for the lower basin.

HYDROPOWER

Prolonged periods of low flow preclude the economical development of hydroelectric power. Most of the water used for power production in the Red River basin functions as cooling water for thermal-electric power plants. Also, the maximum head potential for the Sheyenne River basin is about 70 feet and a very large storage would be required to develop this potential.

CULTURAL RESOURCES

Available data on cultural resources have been assembled from a variety of published and unpublished sources in a report prepared under contract with the St. Paul District. The records indicate 170 known prehistoric American Indian archaeological sites and 133 unverified leads to other sites. Most of these sites are in the upper basin, especially near Lonetree Reservoir where systematic surveys have been carried out by professional archaeologists. The sites include fortified villages, campsites, burial mounds, pictographs, tipi rings, stone alignments, and earthworks.

The area has been continuously occupied for at least 10,000 years. The frequency of sites located in the very limited areas that have been systematically surveyed suggests that the number of presently unknown sites is enormous.

The records of historic sites are more complete, though here again many leads are unconfirmed. The 46 known sites and 60 site leads include fur trading posts, military camps, forts, trails, river crossings, town sites, stage coach and mail stations, mills, and abandoned farmsteads.

Except for a handful of these sites, little can be said today about their relative importance. Before such determinations can be made about the known sites, the sites must be inspected and tested and their current condition and historical significance must be evaluated.

To preserve the limited and unrenewable data about past human life in the area and ensure that information about the past is available to present and future generations, archaeological sites and historic structures in all area of proposed impacts should be identified, protected, preserved, evaluated, enhanced, and interpreted for the public.

FORMULATION OF ALTERNATIVE PLANS

INTRODUCTION

The following paragraphs discuss the alternatives in terms of their flood damage reduction effectiveness, areas of compatibility and conflict, the reasons for dropping or keeping them for further study, and the rationale for grouping specific alternatives to form overall plans. The stage 1 evaluation included initial identification of alternatives and the determination of which alternatives should be evaluated in more detail. In stage 2, the most promising alternatives were combined into flood damage reduction plans, and the plans were evaluated to determine which plans and components should be carried into the final stage of evaluation. In the final evaluation phase, the plans which met the criteria for economic development, environmental quality, and implementability and which met the planning objectives were displayed. At this point, the plan considered to best meet the various considerations was selected.

STAGE 1 EVALUATION

In stage 1, the problems and needs of the basin were identified, and measures to meet these problems and needs were developed and evaluated on the basis of their ability to meet the particular objectives. Although measures for several objectives were developed and considered, only those for flood damage reduction will be discussed here.

In all, 102 measures were identified (see table M-4). The alternatives that had significant potential for reducing flood damdges wer sized and evaluated for their ability to control the 1-percent chance flood in the urban areas. The alternatives that did not have this potential were evaluated to determine what level of protection they could reasonably provide. Plate M-2 shows the locations of these measures.

Table M-4 - Summary of stage 1 evaluations

Flood damage reduction alternative	Rating (1) Economic	Rating (1) Environ-mental
II-A-1. Effects of other rivers	+1	0
2. Effects of drainage	+1	0
3. Geological survey	0	0
4. Economic study of basin	0	0
5. Sociological study of basin	0	0
6. Hydrologic and hydraulic study of RRN basin	+1	0
II-B-1. Basinwide drainage plan	+1	0
2. Regional/basinwide approach to water planning	+1	0
3. Develop out of the floodplain	0	0
4. Better land use planning	+1	+1
II-C-1. Floodplain zoning	+1	+1
2. Floodplain regulations	+1	+1
3. Prohibit replacement of obsolete homes in the floodplain	0	0
4. Control private levee construction	+1	+1
5. Enforce drainage laws	+1	+1
6. Better legislation to control drainage	0	+1
II-D-1. Establish greenbelts	0	+1
2. Financial incentives to retain water on farmland	0	+1
3. Small retention dams	0	+1
4. Provide flood insurance	0	0
5. Eliminate flood insurance on future construction	0	0
II-E-1. Relocate frquently flooded structures	0	0
2. Evacuate floodplain developments	-1	0
3. Flood proofing	-1	0
4. Fall release of Baldhill Dam	0	0
5. Better management of Baldhill Dam	0	-1
III-A-1. Urban levees		
a. Valley City	-2	0
b. Lisbon	-2	0
c. Kindred	-1	0
d. Horace	-2	0
e. West Fargo	+2	0
f. Harwood	-1	0
2. Rural levees		
a. Kindred to Horace	-2	0
b. Horace to West Fargo	+1	0
c. West Fargo to Harwood	0	0
d. Harwood to RRN	-2	0
e. Kindred to RRN	0	0

Table M-4 - Summary of stage 1 evaluations (cont)

	Rating (1)	
Flood damage reduction alternative	Economic	Environ-mental
III-B-1. Sheyenne River diversions		
a. M-19 to RRN via Harwood Slough	-2	0
b. M-30 to M-24 around West Fargo via Drain 21	+2	0
c. M-33 to RRN via Rose Coulee	+2	0
d. M-35 to RRN via Sheyenne diversion	+2	0
e. M-42 to Wild Rice River near Horace	+2	0
f. M-42 to M-24 via Drain 21	+2	0
g. M-54 to Wild Rice River near Norman	+2	0
h. M-65 to Wild Rice River near Kindred	+2	0
i. M-138 to Wild Rice River near Milnor	-2	0
j. M-150 to James River via Taayer Reservoir	-2	0
k. M-155 to James River via Bear Creeek	-2	0
l. M-190 to James River via Bear Creek	-2	0
m. M-195 to James River via Bear Creek	-2	0
III-B-2. Maple River diversions		
a. M-6 to RRN via Drain 13	-1	0
b. M-104 to Sheyenne River via natural valley	-1	+1
III-C-1. Channelize Sheyenne River - Kindred to mouth	+1	-1
2. Channelize Maple River - Durbin to mouth	-1	-1
III-D-1. Enlarge Cass County Drains 13, 21, and 45	0	0
2. Install retention control structure on drains	0	0
3. Modify bridges and highways	0	0
III-E-1. Snag and clear Sheyenne River	0	0
2. Snag and clear Maple River	-1	0
3. Snag and clear Sheyenne River tributaries	-1	0
III-F-1. Restore drained wetlands	0	+1
2. Increase storage capacity of wetlands	0	+1
III-G-1. Dams and reservoirs - Sheyenne River main stem		
a. Kindred (M-76)	+1	-2
b. Highway 18 (M-86)	+1	-2
c. Larson's Bridge (M-110)	0	-2
d. Strong Memorial Park (M-138)	0	-1
e. Lisbon (M-171)	-1	-2
f. Fort Ransom (M-196)	-1	-2
g. Baldhill Dam (M-271)	0	-2
h. Cooperstown (M-320)	0	-2
i. Warwick (M-418)	-2	-1

Table M-4 - Summary of stage 1 evaluations (cont)

Flood damage reduction alternative	Rating (1) Economic	Rating (1) Environmental
III-C-2. Dams and reservoirs - Sheyenne River tributaries		
a. T-83	-1	0
b. T-94	0	0
c. Dead Colt Creek (T-150)	0	0
d. Timber Coulee (T-158)	0	0
e. T-213	+1	0
f. T-240	+1	0
g. T-268	0	0
h. Baldhill Creeek (T-283)	+1	0
i. T-304	+1	0
j. T-308	+1	0
k. T-321	+1	0
l. Pickerel Lake Creek (T-334)	+1	0
m. Lake Norway (T-350)	+1	0
n. Kloten (T-366)	0	0
o. McVille Coulee (T-367)	+1	0
p. Spring Coulee (T-393)	-1	0
q. Robinson Coulee (T-416)	0	0
r. T-438	-1	0
s. T-439	-1	0
t. T-448	-1	0
u. Peterson Coulee (T-453)	-1	0
v. T-460	0	0
w. Big Coulee (T-463)	+1	0
x. North Fork (T-470)	+1	-1
3. Dams and reservoirs - Maple River main stem		
a. Watson (M-76)	0	-1
b. Highland (M-87)	0	-1
c. Enderlin (M-106)	0	-1
4. Dams and reservoirs - Maple River tributaries		
a. South Branch (T-102)	0	0
b. T-104a	-1	0
c. T-104b	-1	0
d. Lucca (T-110)	0	0

(1) Rating: +2 Very good
+1 Good
0 Neutral
-1 Poor
-2 Bad

The environmental, social, and economic impacts of the alternatives were evaluated in as much detail as possible in this early stage of the study. In general, the following factors were identified:

- First cost.
- Average annual cost.
- Urban and agricultural benefits.
- Total flood control benefits.
- Benefit-cost ratio.
- Acres of wildlife habitat affected.
- Numbers of farmsteads, residences, and businesses affected.
- Acres and types of land required.
- Flood damdge reduction effectiveness in particular areas and for the whole Sheyenne River.
- Effectiveness in preventing damages from the 1- and 10-percent chance floods at specific locations along the Sheyenne River.

The assessment of these impacts for each alternative is described in Appendix L.

Once these factors were assessed, the alternatives were rated on their economic contributions, environmental impacts, and implementability. This evaluation used a simplified system of positive, negative, or neutral ratings assigned by an interdisciplinary team of Corps of Engineers personnel with the aid of other agencies. The ratings are summarized in table M-4.

After considering the economic and environmental ratings and the potential for reducing flood damages, the citizens committee and State and Federal agencies evaluated the altenatives' implementability and worthiness to be carried on for further study. The recommendations of the citizens committee and agencies are summarized in table M-5.

Table M-5 - Summary of recommendations by organizations and agencies on the preliminary flood damage reduction alternatives for the Sheyenne River basin, North Dakota

Flood control alternatives	Drop: Citizens Committee	Drop: Corps of Engineers	Drop: ND State Water Comm.	Drop: SCS	Drop: F&WS	Drop: ND Hwys.	Drop: Other	Drop: Consensus	Keep: Citizens Committee	Keep: Corps of Engineers	Keep: ND State Water Comm.	Keep: SCS	Keep: F&WS	Keep: ND Hwys.	Keep: Other	Keep: Consensus	Consensus Summary: Drop	Consensus Summary: Keep
II-A-1. Effects of other rivers									X	X	X	X	(3)	X		Yes		Keep
2. Effects of drainage									X	X	X	X	(3)	X		Yes		Keep
3. Geological survey						X		No	X	X	X	X	(3)			No		(?)
4. Economic study of basin									X	X	X	X	(3)	X		Yes		Keep
5. Sociological study of basin						X		No	X	X	X	X	(3)			No		(?)
6. Hydrologic and hydraulic study of RRN basin									X	X	X	X	(3)	X		Yes		Keep
II-B-1. Basin-wide drainage plan									X	X	X	X	(3)			Yes		Keep
2. Regional/basin-wide approach to water planning									X	X	X	X	(3)			Yes		Keep
3. Develop out of floodplain									X	X	X	X	(3)			Yes		Keep
4. Better land-use planning									X	X	X	X	(3)			Yes		Keep
II-C-1. Floodplain zoning									X	X	X	X	(3)			Yes		Keep
2. Floodplain regulations									X	X	X	X	(3)			Yes		Keep
3. Prohibit replacement of obsolete homes in floodplain	X	X						No			(4)	X	(3)			No	(?)	
4. Control private levee construction									X	X	X	X	(3)			Yes		Keep
5. Enforce drainage laws									X	X	X	X	(3)			Yes		Keep
6. Better legislation to control drainage									X	X	X	X	(3)			Yes		Keep
II-D-1. Establish greenbelts	X	X						No			X	X	(3)			No	(?)	
2. Financial incentives to retain water on farm land									X	X	X	X	(3)			Yes		Keep
3. Small retention dams			X					No	X	X		X	(3)			No		(?)
4. Provide flood insurance	X							No		X	X	X	(3)			No		(?)
5. Eliminate flood insurance on future construction	X	X	X					No				X	(3)			No	(?)	
II-E-1. Relocate frequently flooded structures									X	X	X	X	(3)			YES		Keep
2. Evacuate floodplain developments	X	X	X					No				X	(3)			No	(?)	
3. Flood proofing									X	X	X	X	(3)			Yes		Keep
4. Fall release of water from Baldhill Dam		X	X					No	X			X	(3)			No		(?)
5. Better management of Baldhill Dam			X					No	X	X		X	(3)			No		(?)
III-A-1. Urban levees																		
a. Valley City		X	X	(5)		X		No	X				X			No	(?)	
b. Lisbon		X	X	(5)		X		No	X				X			No	(?)	
c. Kindred		X	X	(5)		X		No	X				X			No	(?)	
d. Horace		X	X	(5)		X		No	X				X			No	(?)	
e. West Fargo		X		(5)				No	X		X		X	X		No		(?)
f. Harwood			X	(5)				No	X	X			X	X		No		(?)
2. Rural levees																		
a. Kindred to Horace	(1)	(2)	X	(5)		X		No					X			No	(?)	
b. Horace to West Fargo	(1)	(2)		(5)		X		No			X		X			No	(?)	
c. West Fargo to Harwood	(1)	(2)	X	(5)				No					X	X		No	(?)	
d. Harwood to RRN	(1)	(2)	X	(5)		X		No					X			No	(?)	
e. Kindred to RRN				(5)		X		No	(1)	(2)	X		X			No		(?)

Table M-5 - Summary of recommendations by organizations and agencies on the preliminary flood damage reduction alternatives for the Sheyenne River basin, North Dakota (cont)

Flood control alternatives	Drop								Keep								Consensus Summary	
	Citizens Committee	Corps of Engineers	ND State Water Comm.	SCS	F&WS	ND Hwys	Other	Consensus	Citizens Committee	Corps of Engineers	ND State Water Comm.	SCS	F&WS	ND Hwys.	Other	Consensus	Drop	Keep
III-B-1. Sheyenne River Diversions																		
a. N-19 to RRN via Harwood Slough	X	X	X	X		X		Yes									Drop	
b. N-30 to N-24 around W. Fargo via Drain No. 21									X	X	X	X	X	X		Yes		Keep
c. N-33 to RRN via Rose Coulee		X					(6)	No	X		X	X	X	X	(6)	No		(?)
d. N-35 to RRN via Sheyenne Diversion		X					(6)	No	X		X	X	X	X	(6)	No		(?)
e. N-42 to Wild Rice River near Horace					X		(6)	No	X	X	X	X		X	(6)	No		(?)
f. N-42 to N-24 via Drain No. 21									X	X	X	X		X		Yes		Keep
g. N-54 to Wild Rice River near Norman					X		(6)	No	X	X	X	X		X	(6)	No		(?)
h. N-65 to Wild Rice River near Kindred					X		(6)	No	X	X	X	X		X	(6)	No		(?)
i. N-138 to Wild Rice River near Milnor	X	X	X	X	X	X	(6)	Yes							(6)		Drop	
j. N-150 to James River via Tasyer Reservoir	X	X	X	X	X	X		Yes									Drop	
k. N-155 to James River via Bear Creek	X	X	X	X		X		Yes									Drop	
l. N-190 to James River via Bear Creek	X	X	X	X		X		Yes									Drop	
m. N-195 to James River via Bear Creek	X	X	X	X		X		Yes									Drop	
2. Maple River diversions																		
a. N-6 to RRN via Drain No. 13	X	X	X	X	X	X		Yes									Drop	
b. N-104 to Sheyenne River via natural valley	X	X	X	X	X	X		Yes									Drop	
III-C-1. Channelize Sheyenne River-Kindred to mouth					X	X		No	X	X	X	X				No		(?)
2. Channelize Maple River-Durbin to mouth		X			X	X		No	X		X	X				No	(?)	(?)
III-D-1. Enlarge Cass Co. Drains Nos. 13, 21, and 45			X		X			No	X	X		X		X		No		(?)
2. Install retention control structure on drains						X		No	X	X	X	X				No		(?)
3. Modify bridges and highways			X			X		No	X	X		X				No		(?)
III-E-1. Snag and clear Sheyenne River	X	X			X	X		No			X	X				No	(?)	
2. Snag and clear Maple River	X	X			X	X		No			X	X				No	(?)	
3. Snag and clear Sheyenne River tributaries	X	X		X	X	X		No			X					No	(?)	
III-F-1. Restore drained wetlands				X		X		No	X	X	X		X			No		(?)
2. Increase storage capacity of wetlands									X	X	X	X	X	X		Yes		Keep

Table M-5 - Summary of recommendations by organizations and agencies on the preliminary flood damage reduction alternatives for the Sheyenne River basin, North Dakota (cont)

Flood control alternatives	Drop: Citizens Committee	Drop: Corps of Engineers	Drop: ND State Water Comm.	Drop: SCS	Drop: F&WS	Drop: ND Hwys	Drop: Other	Drop: Consensus	Keep: Citizens Committee	Keep: Corps of Engineers	Keep: ND State Water Comm.	Keep: SCS	Keep: F&WS	Keep: ND Hwys.	Keep: Other	Keep: Consensus	Consensus Summary: Drop	Consensus Summary: Keep
III-G-1. Dams and reservoirs-Sheyenne River main stem																		
a. Kindred (M-76)					X			No	X	X	X	X				No		(?)
b. Highway 18 (M-86)	X	X			X			No			X	X		X		No	(?)	(?)
c. Larson's Bridge (M-110)	X	X			X	X		No			X	X				No	(?)	
d. Strong Memorial Park (M-138)	X	X	X	X	X	X		Yes									Drop	
e. Lisbon (M-171)	X	X	X	X	X	X		Yes									Drop	
f. Fort Ransom (M-196)	X	X	X	X	X	X		Yes									Drop	
g. Baldhill Dam (M-271)						X		No	X	X	X	X	X			No		(?)
h. Cooperstown (M-320)	X	X	X	X	X	X		Yes									Drop	
i. Warwick (M-418)	X	X	X	X	X	X		Yes									Drop	
2. Dams and reservoirs-Sheyenne River tributaries																		
a. (T-83)	X	X	X	X	(9)	X		Yes									Drop	
b. (T-94)	X		X	X	(9)	X		No		X						No	(?)	
c. Dead Colt Creek (T-150)	X	(8)	X	X	(9)	X		No		(8)						No	(?)	
d. Timber Coulee (T-158)	X		X	X	(9)	X		No		X						No	(?)	
e. (T-213)	X	X	X	X	(9)	X		Yes									Drop	
f. (T-240)	X		X	X	(9)	X		No		X						No	(?)	
g. (T-268)	X	X	X	X	(9)	X		Yes									Drop	
h. Baldhill Creek (T-283)	X	X	X	X	(9)	X		Yes									Drop	
i. (T-304)	X	X	X	X	(9)	X		Yes									Drop	
j. (T-308)	X	X	X	X	(9)	X		Yes									Drop	
k. (T-321)	X	X	X	X	(9)	X		Yes									Drop	
l. Pickerel Lake Creek (T-334)	X	X	X	X	(9)	X		Yes									Drop	
m. Lake Norway (T-350)	X	X	X	X	(9)	X		Yes									Drop	
n. Kloten (T-366)	X	X	X	X	(9)	X		Yes									Drop	
o. McVille Coulee (T-367)	X	X	X	X	(9)	X		Yes									Drop	
p. Spring Coulee (T-393)	X	X	X	X	(9)	X		Yes									Drop	
q. Robinson Coulee (T-416)	X	X	X	X	(9)	X		Yes									Drop	
r. (T-438)	X	X	X	X	(9)	X		Yes									Drop	
s. (T-439)	X	X	X	X	(9)	X		Yes									Drop	
t. (T-448)	X	X	X	X	(9)	X		Yes									Drop	
u. Peterson Coulee (T-453)	X	X	X	X	(9)	X		Yes									Drop	
v. (T-460)	X	X	X	X	(9)	X		Yes									Drop	
w. Big Coulee (T-463)	X	X	X	X	(9)	X		Yes									Drop	
x. North Fork (T-470)	X	X	X	X	(9)	X		Yes									Drop	
3. Dams and reservoirs - Maple River main stem																		
a. Watson (M-76)	X	X	X	X	(9)	X		Yes									Drop	
b. Highland (M-87)	X	X	X	X	(9)	X		Yes									Drop	
c. Enderlin (M-106)			X	X	(9)			No	(7)	X				X		No	(?)	(?)
4. Dams and reservoirs - Maple River tributaries																		
a. South Branch (T-102)		X	X	X	(9)	X		No	(7)							No	(?)	
b. (T-104a)		X	X	X	(9)	X		No	(7)							No	(?)	
c. (T-104b)		X	X	X	(9)	X		No	(7)							No	(?)	
d. Lucca (M-110)		X	X	X	(9)	X		No	(7)							No	(?)	

(1) If rural levee segments are put in, they should be put in all the way; separate or different levee segments may be desirable in conjunction with diversions.
(2) Rural levees in some segments may be desirable in conjunction with diversion alternatives.
(3) Nonstructural alternatives are generally environmentally desirable and should be carried forward.
(4) Needs further public input to determine acceptability.
(5) Insufficient environmental and implementability data to adequately rate.
(6) Minnesota Department of Natural Resources would be opposed to any diversion which increased flood stages along Red River of the North, especially at Moorhead.
(7) Should be kept to provide flood protection for Enderlin.
(8) Could be operated for only very limited amounts of flood control in conjunction with current recreation pool plans.
(9) Generally, the small dam approach is not environmentally desirable; however, in some cases, a few of these might be acceptable.

AD-A146 716 GENERAL REEVALUATION AND ENVIRONMENTAL IMPACT STATEMENT FOR FLOOD CONTROL..(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT JAN 84 4/5

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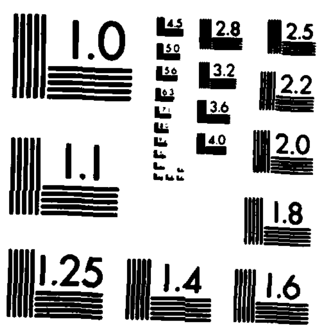


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

On the basis of the recommendations and comments of all concerned interests as well as the economic and environmental impacts, the alternatives were separated into two groups:

1. Alternatives considered in stage 1 but dropped from further consideration.

2. Alternatives still under consideration.

Table M-6 lists the alternatives dropped from further consideration and the reasons for dropping them.

Table M-6 - Alternatives considered in stage 1 but dropped from further consideration

Alternative	Reasons for dropping
Nonstructural	
Prohibit replacement of obsolete homes in floodplain	Because of the vast width of the floodplain and the relatively shallow depth of the flooding in the lower Sheyenne River, flood proofed home construction could be a wise use for portions of the floodplain. With proper regulation and zoning, the effects of such construction on flood height would be insignificant.
Establish greenbelts	This concept by itself would have no flood damage reduction capabilities. In many areas, development has already occurred up to the river's edge. However, this concept does have environmental merit.
Eliminate flood insurance on future construction	This concept would eliminate the premium constraint on floodplain development and thus could encourage uncontrolled construction within the floodplain.

Table M-6 - Alternatives considered in stage 1 but dropped from further consideration (cont)

Alternative	Reasons for dropping
Nonstructural (cont)	
Evacuate floodplain developments	This concept is not economically or socially viable for the entire floodplain because of the extent of development in the floodplain and the vast width of the floodplain, especially in the West Fargo area. However, in Valley City and Lisbon, partial relocation plans may be practical.
Fall release of water from Baldhill Dam	This concept has been included in the revised management of Baldhill Dam alternative.
Structural	
Urban levees at Valley City	Not economically justifiable, and the level of protection exceeds that wanted by the city.
Urban levees at Lisbon	Not economically justifiable, and the level of protection exceeds that wanted by the city.
Urban levees at Kindred	Not economically justifiable, and the level of protection exceeds that wanted by the city.
Urban levees at Horace	Not economically justifiable.
Urban levees at West Fargo	This concept was changed to the combination levees and diversion around West Fargo (M-30 to M-24) alternative because of the problems with levee alignments along the Sheyenne River. Because the homes are close to the riverbank, putting levees along the river would be very costly or may require relocations.
Rural levees Kindred to Horace	Not economically justifiable by itself; it could create more flood damages downstream in the Horace-West Fargo and Harwood areas by the confining effect of the levees. In recognition of this effect, the concept was incorporated in the rural levees at selected reaches from Kindred to RRN alternative.

Table M-6 - Alternatives considered in stage 1 but dropped from further consideration (cont)

Alternative	Reasons for dropping
Structural (cont)	
Rural levees Harwood to RRN	Not economically justifiable by itself; this concept was incorporated in the rural levees at selected reaches from Kindred to RRN alternative.
Sheyenne River diversions	
M-19 to RRN via Harwood Slough	Not economically justifiable by itself; would have little if any effect in reducing flood levels along the Sheyenne River upstream of the confluence with Maple River.
M-33 to RRN via Rose Coulee	Even though this alternative is economically justifiable, its area of protection is smaller than those of the M-42 through M-65 diversions which have similar economics. Dropped in favor of M-42, M-54, or M-65.
M-35 to RRN via Sheyenne diversion	The alternative is economically justifiable; however, the area of protection is smaller than those of the M-42 through M-65 diversions which have similar economics. Dropped in favor of M-42 M-54, or M-65.
M-138 to Wild Rice River near Milnor	Not economically justifiable; high construction costs far exceed possible flood damage reduction benefits.
M-150 to James River via Taayer Reservoir	Not economically justifiable; high construction costs involved in crossing the drainage divide far exceed possible benefits.
M-155 to James River via Bear Creek	Not economically justifiable; high construction costs exceed possible benefits.
M-190 to James River via Bear Creek	Not economically justifiable; high costs far exceed possible benefits.
M-195 to James River via Bear Creek	Not economically justifiable; high construction costs far exceed possible benefits.

Table M-6 - Alternatives considered in stage 1 but dropped from further consideration (cont)

Alternative	Reasons for dropping
Maple River diversion - M-104 to Sheyenne River via natural valley	Not economically justifiable by itself and may have an adverse effect on flood stages along the Sheyenne River.
Channelize Maple River - Durbin to mouth	Both economically and environmentally unsound; little if any flood damage reduction at West Fargo.
Snag and clear Maple River - Durbin to mouth	Economically unsound, would have little if any flood damage reduction effects at West Fargo.
Snag and clear Sheyenne River tributaries	Economically poor, would have little if any flood damage reduction effects along the Sheyenne River.
Dams and reservoirs - Sheyenne River main stem	
Highway 18 (M-86)	Even though economically justifiable, this alternative has less overall flood damage effectiveness than the larger and more economical Kindred site. However, this site could be considered at a later time as an effective alternate to a reduced-size Kindred Dam.
Larson's Bridge (M-110)	This alternative has less overall flood damage effectiveness than the Highway 18 site or the Kindred site. Dropped in favor of the Highway 18 or Kindred sites.
Strong Memorial Park (M-138)	Because of the relatively small size of this reservoir and its location, the flood damage reduction effectiveness would be very low.
Lisbon (M-171)	Not economically justifiable; this alternative has less overall flood damage reduction effectiveness than the more economical Kindred site.
Fort Ransom (M-196)	Not economically justifiable; this alternative's flood damage reduction effectiveness is less than the more economical Kindred site.

Table M-6 - Alternatives considerd in stage 1 but dropped from further consideration (cont)

Alternative	Reasons for dropping
Dams and reservoirs - Sheyenne River main stem (cont)	
Cooperstown (M-320)	The size and location do not offer effective reduction of overall flood damages. Raise of Baldhill Dam would be more effective, more efficient, and less costly.
Warwick (M-418)	Both economically and environmentally unjustifiable; very poor flood damage reduction effectiveness.
Dams and reservoirs - Sheyenne River tributaries	
T-83	Not economically justifiable by itself because of small drainage area controlled and small storage capacity. Also, it is located too far downstream to be effective in reducing the first peak of the Sheyenne River flood. Could actually increase main flood peaks under some conditions.
T-213	Not economically justifiable by itself because of major relocations. Also, because of its location, its effects will be on the recession side of the first peak flood hydrograph.
T-268	Not economically justifiable by itself because of major relocations. Also, because of its location, its effects will be on recession side of the first peak flood hydrograph.
T-283 Baldhill Creek; T-304; T-308; T-321; T-334 Pickerel Lake Creek; T-350 Lake Norway; T-366 Kloten; T-367 Mc Ville Coulee; T-393 Spring Coulee	These tributary dams would have no effect on the first peak of Sheyenne River floods. Also, any effect they would have on the second peak could be achieved more economically and effectively with a very minor raise of Baldhill Dam.

Table M-6 - Alternatives considered in stage 1 but dropped from further consideration (cont)

Alternative	Reasons for dropping
Dams and reservoirs - Sheyenne River tributaries (cont)	
T-416 Robinson Coulee; T-438; T-439; T-448; T-453 Peterson Coulee; T-460; T-463 Big Coulee; T-470 North Fork	These tributary dams would have no effect on either the first or second peak of Sheyenne River floods because of their location in the upper part of the watershed.
Dams and reservoirs - Maple River main stem	
M-76 Watson M-87 Highland	Both of these dams would have limited effects on flows in the Sheyenne River below the mouth of the Maple River and at West Fargo. Similar effects plus a major reduction of flood flows along the Maple River at Enderlin could be achieved with the M-106 Enderlin Dam alternative.
T-102 South Branch; T-104a; T-104b; T-110 Lucca	These dams would have little effect on flood flows in the Sheyenne River. The Maple River main stem dam (M-106, Enderlin) alternative would be more economical and effective than these four reservoirs in reducing Maple River flows and in affecting flows on the Sheyenne River.

The altenatives carried on for consideration in stage 2 are listed in table M-7. These alternatives are presented in three categories: (1) those alternatives that would be part of existing and/or future base conditions, (2) those alternatives that could be considered minor components of a flood damage reduction plan, and (3) those alternatives that could be considered major components of a flood damage reduction plan.

Table M-7 - Alternatives carried into stage 2

Alternative measures that would be considered as part of the existing and future base conditions

Effects of other rivers
Effects of drainage
Geological survey
Economic study of basin
Sociological study of basin
Hydrologic and hydraulic study of RRN basin
Basinwide drainage plan
Regional/basinwide approach to water planning
Better land use planning
Floodplain zoning
Floodplain regulations
Control of private levee construction
Enforcement of drainage laws
Flood insurance

Alternative measures that would be considered as minor components of an overall plan

Develop out of floodplain
More stringent legislation to control drainage
Financial incentives to retain water on farmland
Small retention dams
Relocate frequently flooded structures
Flood proofing
Revised management of Baldhill Dam
Urban levees at Harwood
Rural levees from Horace to West Fargo
Rural levees from West Fargo to Harwood
Rural levees at selected reaches from Kindred to the RRN
Maple River diversion M-6 to RRN via drain No. 13

Table M-7 - Alternatives carried into stage 2 (cont)

Alternative measures that would be considered as minor components of an overall plan (cont)
Drainage, ditches, bridges, etc.:
Enlarge Cass County drains Nos. 13, 21 and 45
Install retention control structures on drains
Modify bridges and highways
Snag and clear Sheyenne River
Wetlands:
Restore drained wetlands
Increase storage capacity of wetlands
Tributary dams and reservoirs
Iron Springs (T-94)
Dead Colt Creek (T-150)
Timber Coulee (T-158)
T-240
Maple River main stem dam and reservoir (M-106) Enderlin
Alternative measures that would be considered as major components of an overall plan
Levees and diversion M-30 to M-24 around West Fargo
Sheyenne River diversion M-42 to Wild Rice River near Horace
Sheyenne River diversion M-42 to M-24 via drain No. 21
Sheyenne River diversion M-54 to Wild Rice River near Norman
Sheyenne River diversion M-65 to Wild Rice River near Kindred
Channelize Sheyenne River Kindred to mouth.
Dams and reservoirs - Sheyenne River main stem
Kindred (M-76)
Baldhill Dam (M-271)

STAGE 2 EVALUATION

General

The alternatives listed in table M-7 were evaluated in further detail during stage 2. This evaluation included a more refined and detailed engineering design of the alternatives, resulting in revised cost estimates as well as improved estimates of flood damage reduction effectiveness and environmental and social impacts. For most alternatives, several designs were developed so that the most cost-effective and beneficial designs could be selected for inclusion in the plans. The more detailed information, including costs, benefits, environmental impacts, social impacts, and flood damage reduction effectiveness, for each alternative carried into stage 2 is summarized in Appendix L.

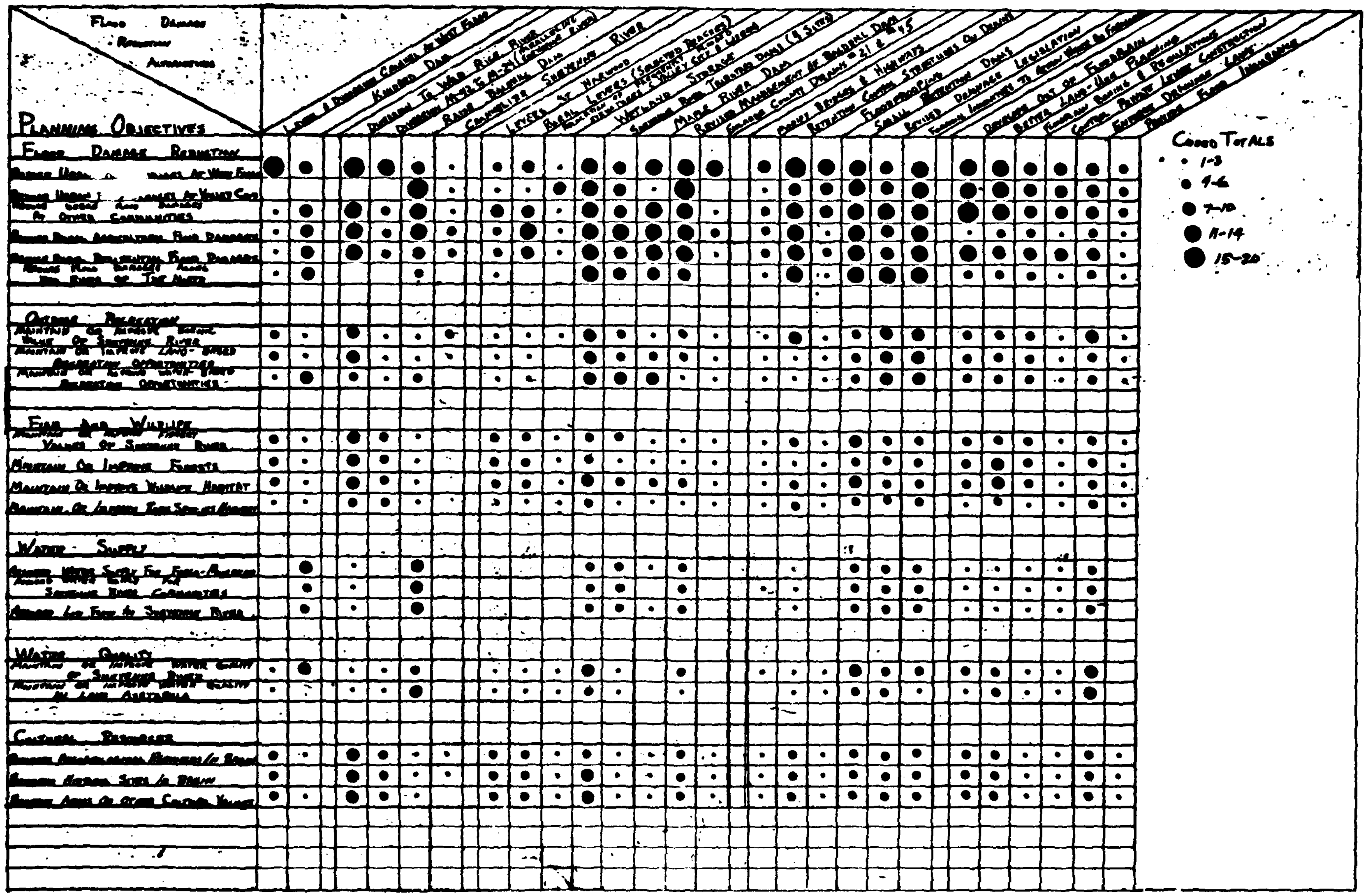
The level of detail used for the evaluation varied. The alternatives considered for inclusion as major components of plans were evaluated in more detail than those considered for inclusion as minor components or as part of the existng or future base condition. Implementability analyses were conducted on the remaining alternatives. The alternatives were then compared and grouped into seven flood damage reduction plans. A comparison of these plans and recommendations on which plans should be carried forward for final evaluation are described in the following paragraphs.

Implementability Analysis

Relative implementability was documented using two methods. Although neither analysis can be used to assess whether an alternative is implementable, taken together, the two analyses indicate potential difficulties for implementing a particular alternative.

The first analysis was a compilation of the views of the representatives of the Lower Sheyenne River Citizens Committee on the relationship of the various measures to the planning objectives. An indication of which alternatives were compatible and which were in conflict with the planning objectives was obtained. Table M-8 summarizes the results of this analysis.

Table M-8 - Potential compatibility for meeting planning objectives[1]

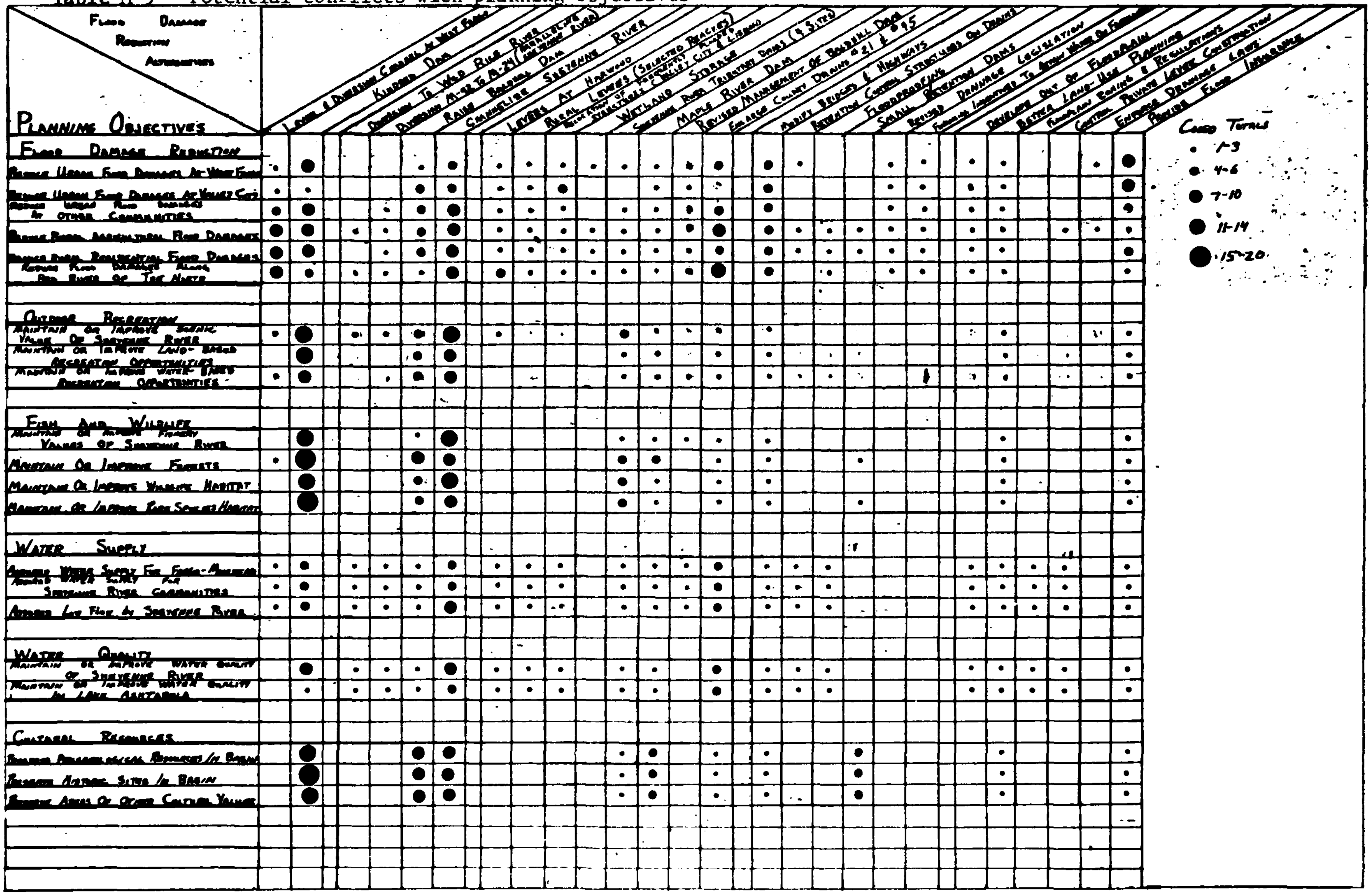


(1) Lower Sheyenne River Citizens Committee responses, 26 March 1979.

The relative value of the compatibility response is greatest for the potential addition or meeting of objectives other than flood damage reduction. The perceptions of the committee members show that the water storage alternatives are compatible with more ensured water supplies, improved water quality, and more water-based recreation. However, on the basis of the number of responses, committee members indicated compatibility more often for the less controversial and less effective measures. The compatibility responses for an alternative in the flood damage reduction objectives do not necessarily relate to the actual effectiveness of the alternative but rather to the collectively perceived acceptability of the alternative. Thus, the responses on compatibility may be used as a partial indicator of which alternatives may be most readily implemented.

Table M-9 summarizes the responses of the committee members regarding the conflicts of the flood damage reduction alternatives with other planning objectives. The conflict presentation indicated the two alternatives perceived as having the greatest potential for conflicts are Kindred Dam and channelization of the Sheyenne River. Enlargement of county drains, raise of Baldhill Dam, and the levees and diversion at West Fargo also produced some evidence of conflict. These conflicts indicate potential implementability problems. Also, a comparison of the conflict areas with the actual effects of the alternative based on technical analysis indicates areas where perceived effects differ from predicted effects. These conflict and compatibility displays can be used with the technical analyses to identify problem areas that may affect the implementability of the various alternatives.

Table M-9 - Potential conflicts with planning objectives (1)



(1) Lower Sheyenne River Citizens Committee responses, 26 March 1979

The second analysis was a technically-oriented procedure developed for this study to identify the plans that are "management actions capable of being implemented based on their institutional and technological feasibility, and on their acceptability to some segment of the affected public." This analysis was conducted by social scientists and water resource planners from the Corps of Engineers.

The implementability factors used were derived from the concerns which determine the viability of an alternative. Most of these factors were derived from the ER 1105-2-200 (multiobjective planning framework) series and implied in the Principles and Standards. The other factors were derived from professional knowledge of public involvement, decision making, and conflict theory.

The procedure includes a display and analysis format to evaluate a set of alternatives with respect to the factors that determine implementability. The function of this procedure is twofold. First, because it employs a systematic method, the implementability analysis can be replicated and is consistent in its treatment of each alternative. Second, the procedure separates implementability into its primary determinants, allowing a more direct analysis. These two functions combine to allow more accurate projections of the implementability of the alternatives. This process provides a greater "guarantee" of time and cost effectiveness by limiting final sets of alternatives to only those that have a strong potential for implementation. Also, the implementability analysis procedure will identify problem areas within alternatives and direct "trouble-shooting" efforts toward those components, increasing the viability of specific alternatives. In general, significant differences are defined as those which involve changes in direction of effect (e.g., 4+/0- to 0+/4-), rather than changes in magnitude (e.g., 4+/0- to 6+/0-). The latter differences generally reflect new information which becomes available during the study.

The assessment procedure consists of the evaluation and scoring of six major criteria affecting implementability. Each criterion, in turn, consists of several component factors. The factors used to assess implementability are presented in table M-10 along with some method definitions and descriptions of the use of the instrument for the Sheyenne River flood damage reduction alternatives.

Table M-10 - Assessment factors

A. INSTITUTIONAL CONSTRAINTS

1. Lack of organizational implementing authority. Is there an organization or group in the area which has the authority to implement the action? Are they willing to implement it?

2. Conflicting agency directives. Does the plan cause conflict between two or more agencies (local, county, regional, State, Federal) that share a common jurisdiction but have competing goals?

3. Jurisdictional overlap of authority. Will the plan require complex and difficult coordination because of a large number of organizations/agencies with some partial responsibility or authority for decision making?

B. CONFLICT AMONG COMPETING INTERESTS/PURPOSES

1. Extensive harm to some concerns to maximize others in the development of a single purpose. Will an alternative cause additional harm or losses in already vulnerable or scarce resources? Is this amount of loss acceptable, given the benefits to other concerns or purposes?

2. Foreclosure of opportunities to develop secondary purposes in maximizing a major purpose.

   a. Will the plan involve a permanent commitment of a resource to one primary purpose? Is this commitment acceptable? How much of a commitment is acceptable?

   b. Would the development and implementation of the primary objective be compatible with development of other objectives?

C. CONTROVERSY LEVELS IN THE PROJECT AREA

1. Substantial opposition to specific alternatives and closure of attitudes on variations. Will the opposition which has developed to date allow the alternative to be reconsidered on its merits, or are attitudes closed?

2. Potential for general opposition to an action on the basis of:

   a. Conflicting agency determinations of plan effects, feasibility. Do differences exist between agencies as to the effects or feasibility of the plan?

   b. Perceptions of effects as distinct from determinations of effect. Do local perceptions of the effects of the plan differ from those of the Corps? Other agencies?

   c. General attitudes toward Federal intervention. Does the type of Federal intervention in "local matters" involved in this plan reduce the possibility of implementation? What would be the local attitudes toward this type of Federal intervention?

D. EQUITABLE DISTRIBUTION OF COSTS AND BENEFITS

1. Avoiding imposing hardships or costs on those who do not benefit from an action.

   a. What would be the nature of the hardships or costs involved - permanent or temporary? Partial or total?

   b. Is the amount of hardship or cost that a group would have to bear acceptable, considering the good of others who benefit? Is the distribution of cost or hardship unfair, considering factors of special vulnerability such as age, low income, or present scarcity of the resource(s) affected?

   c. How much are you willing to burden or take from some people to give others what they want? (This judgment should be tempered by how well off and able to fend for themselves the members of each group are.)

2. Allocating major local costs to those who are also the major beneficiaries.

   a. Is the distribution of benefits from the action a major factor in determining the distribution of costs?

   b. Is the degree of hardship or cost borne fair, considering the amount of benefits that the group receives?

Table M-10 - Assessment factors (cont)

E. DEGREE TO WHICH ALTERNATIVE ADDRESSES PLANNING OBJECTIVES

1. Local perceptions of necessity for the action. Is the alternative necessary to solve the problems that exist?

2. Local perception of providing acceptable degrees of action.

   a. Does the plan adequately provide for the needs of the study area?

   b. Does it adequately provide for the needs of other areas?

   c. Is the plan an effective solution to existing problems?

F. AGENCY CONSTRAINTS

1. Value of the adapted technique. Is the benefit received reasonable in relation to the cost of doing it this way?

2. Feasibility of the adapted technique. Will it take so long to get it done that changing conditions and attitudes may hinder its completion.

The assessment factors were evaluated on the basis of their relative impacts -- "positive", "negative", or "neutral". In principle, the distinctions among "negative", "neutral", and "positive" should be able to be reduced to a standard quantitative set of cut-point rules. However, a number of problems hinder this degree of standardization. Cutoff points have to reflect the severity of impacts, which varies according to the specific plan and the local public's perceptions of that plan.

The implementability analysis procedure is explicit enough to allow considerable participation by study team members who are not social scientists. It does not, however, eliminate the need for professional judgments conserning the potential human responses to particular alternatives. Instead, it provides some criteria to direct that judgment. These criteria are as follows: (1) judgments of intensity and direction of effect are situation-specific with regard to preferences of study

area citizens, (2) the subjective perceptions of local individuals as well as the "objective facts" are considered in arriving at a rating, and (3) justifications for each rating should be available on request from the assessor if the ratings are objectionable (they could be presented for each case, but the total number of cases being evaluated makes this undesirable).

The criteria for a "positive", "neutral", or "negative" rating are as follows:

Positive (+)

1. Takes advantage of an opportune situation in providing a benefit to implementation.

2. Responds to a widespread public demand.

Neutral (0)

1. Neutral effect.

2. Imposes no liability and gives no benefit.

Negative (-)

1. Substantial negative effect on a legitimate concern.

2. Would create public opposition to the plan.

3. Would be extremely difficult to achieve.

The evaluations of the principal flood damage reduction alternatives considered in stage 2 are summarized in table M-11.

Table M-11

SUMMARY OF IMPLEMENTABILITY ASSESSMENT FOR FLOOD DAMAGE REDUCTION ALTERNATIVES

IMPLEMENTABILITY ASSESSMENT FACTORS \ FLOOD DAMAGE REDUCTION ALTERNATIVES	Basin-wide [illegible]	Basin-wide [illegible]	Development out of Flood-plain	Better Land-use Planning	Floodplain Zoning	Floodplain Regulations	Private Levee Construction	Drainage Laws	Control Drainage	Financial Incentives	Small Retention Dams	Flood Insurance	Relocation of Frequently Flooded Structures	Flood Proofing (Ring Levees)
A.) INSTITUTIONAL CONSTRAINTS														
1. Lack of authority	-	0	-	0	0	0	0	0	0	0	0	0	-	0
2. Conflicting directives	-	-	-	0	0	0	0	-	-	0	0	0	0	0
3. Overlap of authority	-	-	-	-	-	-	-	0	-	0	0	0	-	-
B.) CONFLICT AMONG INTERESTS														
1. Relative Inequity	+	+	0	0	0	0	+	+	0	+	0	0	0	0
2. Foreclosure of opp.	0	+	0	0	0	0	0	0	0	0	0	0	0	0
C.) CONTROVERSY LEVELS														
1. Substantial opposition	0	+	0	0	0	0	+	0	0	0	0	0	0	0
2. General opposition														
a.) Conflicting Determin.	0	0	0	0	0	0	0	0	0	0	0	0	0	-
b.) Perception Effects	0	0	0	0	0	0	0	0	0	0	0	0	0	0
c.) Attitude to Fed. Inter.	0	0	-	0	0	0	-	-	-	0	0	+	-	0
D.) EQUITABLE DISTR. OF C&B														
1. Impacts other than benef.	+	0	0	+	+	+	+	+	+	+	0	0	+	0
2. Beneficiaries pay share	0	0	+	+	+	+	0	0	0	+	0	+	0	+
E.) ADDRESSING OBJECTIVES														
1. Perception of need	+	+	0	+	+	0	+	+	+	+	0	+	0	0
2. Perception of needed deg.	+	+	0	0	0	0	0	0	0	0	0	0	0	0
F.) AGENCY CONSTRAINTS														
1. Technique value	+	+	0	+	+	+	0	+	+	0	0	0	0	0
2. Technique feasibility	0	0	-	0	-	-	-	0	0	0	0	0	0	0
TOTALS +/-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0+/0-	[illegible]	1+/3-	[illegible]

IMPLEMENTABILITY ASSESSMENT FACTORS \ FLOOD DAMAGE REDUCTION ALTERNATIVES	Revised Management of Baldhill Dam	Urban Levees at Harwood	Rural Levees: (Kindred to Horace)	Rural Levees: (West Fargo to Harwood)	Rural Levees at selected reaches from Kindred to RRN	Maple R. Diversion (N-6) to RRN	Enlarge Cass Co. Drains No. 13, 21, and 45	Install retention control structures on Drains	Modify bridges and highways	Snag & clear Sheyenne River	Restore drained wetlands	Increase storage capacity of wetlands	Tributary Dam T-94	Tributary Dam T-150
A.) INSTITUTIONAL CONSTRAINTS														
1. Lack of authority	0	0	-	-	-	-	0	-	0	0	-	-	0	+
2. Conflicting directives	-	0	0	0	0	0	0	-	0	0	0	0	-	-
3. Overlap of authority	0	0	0	0	0	0	0	-	0	0	-	0	0	0
B.) CONFLICT AMONG INTERESTS														
1. Relative Inequity	-	0	0	0	0	0	0	0	0	0	0	0	0	0
2. Foreclosure of opp.	0	0	0	0	0	0	0	0	+	0	0	+	-	+
C.) CONTROVERSY LEVELS														
1. Substantial opposition	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. General opposition														
a.) Conflicting Determin.	0	0	0	0	0	0	0	0	0	-	0	+	0	0
b.) Perception Effects	-	0	0	0	0	-	0	0	0	0	0	0	0	0
c.) Attitude to Fed. Inter.	0	0	0	0	0	0	0	-	0	0	-	-	0	0
D.) EQUITABLE DISTR. OF C&B														
1. Impacts other than benef.	-	0	0	0	0	-	0	+	0	0	+	+	0	+
2. Beneficiaries pay share	0	0	0	0	0	0	0	+	0	0	0	0	-	0
E.) ADDRESSING OBJECTIVES														
1. Perception of need	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. Perception of needed deg.	0	+	0	0	0	0	0	0	0	0	0	0	0	0
F.) AGENCY CONSTRAINTS														
1. Technique value	+	+	-	0	0	0	0	0	0	0	0	0	0	+
2. Technique feasibility	+	+	0	0	0	0	0	0	0	0	-	-	0	0
TOTALS +/-	2+/4-	[illegible]	[illegible]	0+/1-	0+/1-	0+/5-	0+/0-	2+/4-	1+/0-	0+/1-	1+/4-	2+/3-	0+/5-	3+/1-

IMPLEMENTABILITY ASSESSMENT FACTORS \ FLOOD DAMAGE REDUCTION ALTERNATIVES	Tributary Dam T-159	Tributary Dam T-240	Maple R. Enderlin Dam (M-105)	Levees and Diversion M-24 around West Fargo	Sheyenne R. Diversion M-30 to Wild Rice River	Sheyenne R. Diversion M-42 to via. Drain No. 21	Sheyenne R. Diversion M-42 to Wild Rice River	Sheyenne R. Diversion M-54 to Wild Rice River	Channelization of Sheyenne R. M-65 to Kindred to mouth	Kindred Dam (near site cap.)	Kindred Dam (reduced size)	Baldhill Dam (greater than 5')	Baldhill Dam (up to 5' raise)
A.) INSTITUTIONAL CONSTRAINTS													
1. Lack of authority	0	0	-	0	-	-	-	-	-	-	-	0	0
2. Conflicting directives	0	-	-	0	0	0	0	0	-	-	-	0	0
3. Overlap of authority	0	0	0	0	0	0	0	0	0	-	-	0	0
B.) CONFLICT AMONG INTERESTS													
1. Relative Inequity	0	0	-	+	0	0	0	0	-	-	-	-	-
2. Foreclosure of opp.	0	-	0	0	0	0	0	0	-	-	0	0	0
C.) CONTROVERSY LEVELS													
1. Substantial opposition	0	0	0	0	0	0	0	0	0	-	-	0	0
2. General opposition													
a.) Conflicting Determin.	0	0	0	0	0	0	0	0	-	-	-	0	0
b.) Perception Effects	0	0	-	-	0	-	0	0	0	-	-	-	0
c.) Attitude to Fed. Inter.	0	0	0	0	0	0	0	0	0	0	0	0	0
D.) EQUITABLE DISTR. OF C&B													
1. Impacts other than benef.	+	0	-	0	+	-	+	+	-	-	-	-	0
2. Beneficiaries pay share	0	-	0	+	0	0	0	0	0	-	-	0	-
E.) ADDRESSING OBJECTIVES													
1. Perception of need	0	0	-	+	+	0	+	+	0	+	+	-	0
2. Perception of needed deg.	0	0	0	0	0	0	0	0	0	+	+	0	0
F.) AGENCY CONSTRAINTS													
1. Technique value	0	0	-	+	+	+	+	+	0	+	+	+	0
2. Technique feasibility	0	0	-	0	0	0	0	0	0	-	-	0	0
TOTALS +/-	1+/0-	0+/5-	0+/8-	4+/1-	3+/1-	1+/3-	3+/1-	3+/1-	0+/6-	[illegible]	[illegible]	[illegible]	[illegible]

The plans that affected four or more assessment factors either positively or negatively were considered to be potentially significant from an implementability standpoint. Some of these and other alternatives are discussed in further detail below.

Relocation of frequently flooded structures (1+/3-) - This alternative would have some legal implementation problems because of conflicts with town and township authorities. It would serve the concerns of the agency regarding floodplain development and environmental preservation. This alternative would not solve all the flood problems of the local area, but could function as a component of an effective composite plan. Local perceptions vary with the area being considered. Factors affecting local attitudes include perception of flood risk, property values, land use type, and proportion of the local community involved.

Revised management of Baldhill Dam (2+/4-) - Although this plan has relatively few significant effects, it does have a positive implementation value. The plan is perceived locally as helpful to problem resolution and as a partial solution to many of the local problems in the upper portions of the basin. This plan could serve to smooth the implementation of a composite plan by providing for the needs of a portion of the basin not aided by most of the major plan components. The effects on the Lake Ashtabula fishery and an ensured water supply must be considered in the overall assessment.

Rural levees at selected reaches, Kindred to RRN (0+/1-) - Conflicts would arise on this alternative as a result of overlapping authorities at the State, county, and township levels. This conflict would adversely affect purposes other than flood control. Some benefits would result through protection of agricultural lands, and this plan would avoid the equity problems of short portions of levees. Some portions of the rural levee system might be worthwhile in providing stopgap protection for reaches not covered by major plan elements.

Levees and diversion around West Fargo, M-30 to M-24 (4+/1-) - Local farmers have expressed some concern that this alternative would interfere with the normal operation of the drain. Some jurisdictional problems might arise with the county. Downstream interests have expressed concern that this alternative would worsen their flood problems. Apart from these problems, the alternative has few disadvantages and meets major flood damage reduction standards.

Levees and diversion around West Fargo, M-42 to M-24 (1+/3-) - The major difference between this alternative and the M-30 to M-24 diversion is the potential for minor increases in flood stages downstream. This potential increase would reduce the distributive equity of and local support for the alternative. This alternative would also require some mitigation measures which, in turn, may disrupt the local area. When combined with other plan components, the downstream effects should be minimized.

Sheyenne River diversions, M-42 to Wild Rice River (3+/1-), M-54 to Wild Rice River (3+/1-), and M-65 to Wild Rice River (3+/1-) - These alternatives are similar in degree of implementability. They would add to the overall implementability of composite plans by providing flood protection at low cost to the natural environment. None would preclude the development of other purposes. Obtaining the necessary legal/jurisdictional authority would be a minor legal problem. The potential for adverse effects exists along the Wild Rice and Red Rivers.

Channelize Sheyenne River, Kindred to mouth (0+/6-) - This plan would be difficult to implement. Interagency conflicts would arise as a result of effects on the natural environment. The plan would allow little possibility for development of secondary purpose benefits and would not increase flood damage reduction enough to compensate for its higher negative effects on other valid concerns.

Restore drained wetlands (1+/4-) - This alternative would require developing new authorities for controlling wetlands for flood storage. It would be heavily opposed by farming interests who would not want to give up lands already drained for agricultural use. It could be part of a composite plan by offering benefits that could compensate for losses resulting from other plan elements.

Increase storage capacity of wetlands (2+/3-) - This alternative incorporates the positive aspects of the wetland restoration alternative but avoids some of the impediments to implementation from legal constraints and local opposition. This alternative would serve well as an element in a composite plan by providing benefits to several purposes and partially canceling the adverse effects of other plan elements. Federal land ownership would concern local interests.

Kindred Dam, reduced size (3+/10-) - Because of the extensive discussion and development of this alternative, it shows the greatest number of significant effects. This plan would serve the major purpose--flood control--to the most acceptable level of all alternatives in the reach below Kindred. However, this plan would negatively affect those who would not benefit from its operation. Either alone or as a component in a larger plan, this alternative would have major implementation problems and face a high level of local controversy. Reduction in storage capacity is not expected to reduce the negative impacts or improve local attitudes enough to change the relative problems of implementation.

Baldhill Dam, up to 5-foot raise (0+/2-) - As an element in a composite plan, this alternative could provide greater protection for Valley City and other locations. Local interest and concern are sufficient to suggest that some change at Baldhill Dam would be implementable (i.e., revised operating plan or a raise of 5 feet or less). A higher raise would be difficult to develop. The major limiting factor would be the impact and extent of relocations of residences and summer cottages surrounding the existing reservoir.

Formulation into Plans

On the basis of the additional information available in Appendix L; the implementability analysis described in the preceding paragraphs; the views expressed by Federal, State, and local interests; and other data and information available on the natural resources of the basin and the effects of the alternatives, an interdisciplinary team of water resource technical experts developed a set of meaningful flood damage reduction plans. The team included specialists in hydrology, hydraulics, economics, forestry, wildlife biology, social sciences, real estate, cultural resources, and water resource planning. Their goal was to combine the various components into plans that would reduce flood damages to an "acceptable" degree.

In the development stage, the best combination of component sizes of given alternatives was selected to provide a plan with the "optimum" combination of cost effectiveness, environmental quality considerations, social well-being considerations, and flood damage reduction effectiveness. All the alternatives listed under "Part of the Existing and/or Future Base Condition" in Appendix L were considered as part of the base condition. Other alternatives were added to that base condition.

Central to plan development was the assumption that the urban area of West Fargo/Riverside must be a focal point because it has the greatest potential for flood damage, accounting for about 68 percent of basin damages. To relieve the flood problems at West Fargo/Riverside, local protection or major main stem reservoir storage would be key elements. Thus, the combination levees and diversion (M-30 to M-24) and Kindred Dam were the key components on which the plans were based. Four plans were developed from the levee and diversion concept: D-1, D-2, D-3, and D-4. Three plans were developed from the Kindred Dam concept: K-1, K-2, and K-3. The manner in which the various alternatives could function effectively in reducing flood damages was the major consideration in adding the various components to the plan. Thus, the two-peak flooding phenomenon along the lower Sheyenne River was very important in plan development.

Description and Summary of Stage 2 Plans

The data on and description of the plans considered in stage 2 and discussed in the following paragraphs is as presented during stage 2 evaluation. Costs and benefits are presented at October 1978 price levels. The effects presented are based on the conditions and evaluations available or known at that time. The costs, benefits, impacts, etc., are comparable between these plans; however, they may be significantly different from the information presented on the final plans.

Plan D-1 - Table M-12 summarizes pertinent information for plan D-1. Plate M-3 shows the location of the plan components. The levees and diversion around West Fargo/Riverside (M-30 to M-24) are the major components of the plan. In the West Fargo/Riverside area, the plan would reduce damages for the first and second peaks on the Sheyenne River as well as backwater effects from the Maple, Rush, and Red Rivers. The diversion to the Wild Rice River (M-54) is another component of plan D-1. This M-54 diversion was selected over the other two diversions (M-42 and M-65) because it is more economically and socially effective. All the diversions would reduce flood damages caused by the second peak on the Sheyenne River because they would not divert water to the Wild Rice River when it might affect the peak stages on the Red River at Fargo. Flood peaks on the Red River at Fargo usually coincide with the first peak on the Sheyenne River, making diversion M-54 inoperable during this period.

Because of their locations and ability to control the first peak, tributary dams T-150 and T-158 were selected to reduce flood damages from the first peak of the Sheyenne River in those areas outside the leveed area at West Fargo/Riverside in the reach from Kindred to the mouth of the Sheyenne River. These two dams were selected over the T-94 and T-240 alternatives because they would be more economical, environmentally sound, and socially effective. They would reduce first peaks from just downstream of Lisbon to the Red River; effects would be most pronounced for the more frequent floods in the 5- to 10-percent chance recurrence frequency range. However, the structures would also reduce flood damages in areas downstream of the mouth along the Red River and large floods in the Kindred-West Fargo area.

To enhance its effectiveness for first peak flooding, the plan may include restoration of drained wetlands, increasing the storage capacity of existing wetlands, and/or putting control structures on legal drains from Baldhill Dam to Kindred. This wetland alternative would affect the more frequent floods in the same manner as the tributary dams. However, the combination of these elements and the tributary dams would provide notably reduced flood stages.

Revised management and/or a raise of Baldhill Dam (up to 5-feet) was added to reduce flood levels at Valley City and help control the second peak from Baldhill Dam to the Red River.

In summary, plan D-1 addresses first peak flooding along the Sheyenne River from the mouth to near Lisbon with the levees and diversion around West Fargo/Riverside (M-30 to M-24), tributary dams T-150 and T-158, and wetland restoration. Second peak flooding from the mouth to Baldhill Dam would be reduced by the levees and diversion around West Fargo (M-30 to M-24), diversion M-54 to the Wild Rice River, and revised management and/or raise of Baldhill Dam (up to 5-feet). As shown in table M-12 (at October 1978 price levels and conditions), the total cost could range from $24.5 to $44.5 million; the average annual cost would range from $2.1 to $2.9 million.

Total benefits would range from $3.11 to $3.49 million, resulting in a benefit-cost ratio of 1.2 to 1.5. Most of these benefits are attributable to the levees and diversion around West Fargo/Riverside, although potential recreation benefits could be added at the tributary dams. The Baldhill Dam alternative would involve the largest possible number of relocations, while the wetlands alternative would require acquisition of the largest number of acres of land for implementation. This plan as a whole would reduce total Sheyenne River flood damages 49 to 55 percent.

Table M-12

SUMMARY OF PLAN D-1

COMPONENTS OF PLAN D-1 / DATA PARAMETERS	LEVEES AND DIVERSION AT WEST FARGO (M 30 to M 24)	DIVERSION TO THE WILD RICE RIVER (M-54)	REVISE MANAGEMENT and/or RAISE OF BALDHILL DAM (UP TO A 5 FOOT RAISE)	TRIBUTARY DAMS: T-150 DEAD COLT CREEK (multi-purpose)	TRIBUTARY DAMS: T-158 TIMBER COULEE	RESTORATION OF DRAINED WETLANDS, INCREASE STORAGE CAPACITY OF EXISTING WETLANDS, and/or PUT CONTROL STRUCTURES ON LEGAL DRAINS FROM BALDHILL DAM TO LINDRED	TOTAL
*PERTINENT DATA:							BALDHILL: 14,000 TO 44,000
Flood Control Storage (acre-feet)	—	—	14,000 TO 44,000	5,000	5,700	—	T-150: 5,000 T-158: 5,700
Design Discharge (cfs) [1]	3400	2,000	2,500	—	—	—	—
Level of Protection [1]	1%	—	—	—	—	—	—
*ECONOMICS:							
COSTS							
First Cost ($ million)	$14 TO $17	$3 TO $5	0 TO $12	$0.8 TO $1.8	$0.7 TO $1.7	$6 TO $7	$24.5 TO $44.5
Annualized Cost ($1000)	$1,100	$290	0 TO $800	$120	$110	$480	$2100 TO $2900
BENEFITS							
Flood Control ($1000)							
West Fargo	$ 2,200	YES (2ND PEAK)	YES (2ND PEAK)	YES (1ST PEAK)	YES (1ST PEAK)	YES (1ST PEAK)	$2300
Valley City	—	—	$60 TO $440	0	0	—	$60 TO $440
Agricultural	—	YES (2ND PEAK)	YES (2ND PEAK)	YES (1ST PEAK)	YES (1ST PEAK)	YES (1ST PEAK)	$200
Other - downstream of West Fargo	—	YES (2ND PEAK)	YES (2ND PEAK)	YES (1ST PEAK)	YES (1ST PEAK)	YES (1ST PEAK)	} $500
Other - upstream of West Fargo	—	YES (2ND PEAK)	YES (2ND PEAK)	YES (1ST PEAK)	YES (1ST PEAK)	YES (1ST PEAK)	
Other - (see note) [2]	—	—	—	RRN	RRN	RRN	RRN (< $50)
SUBTOTAL - Flood Control	$2,200	—	MORE THAN $60 TO $970	—	—	—	$3110 TO $3490
Potential for other types of Benefit	RECREATION	—	—	RECREATION, WATER SUPPLY	RECREATION, WATER SUPPLY	FISH & WILDLIFE	RECREATION, WATER SUPPLY, FISH & WILDLIFE
TOTAL BENEFITS ($1000)	$2,200	(NOT SEPARABLE)	(NOT SEPARABLE)	(NOT SEPARABLE)	(NOT SEPARABLE)	(NOT SEPARABLE)	$3110 TO $3490
B/C RATIO	2.0	—	—	—	—	—	1.2 TO 1.5
NET BENEFITS ($1000) [3]	$1,100	—	—	—	—	—	$590 TO $1010
*ENVIRONMENTAL EFFECTS:							
Woodlands Affected (acres) [4]	2	5	0 TO 185	40	30	[5]	77 (0.3%) TO 262 (1.0%)
Wetlands Affected (acres) [4]	18	—	0 TO 260	—	—	[5]	18 (0.1%) TO 278 (0.6%)
Grasslands Affected (acres) [4]	54	12	0 TO 594	260	200	[5]	526 (0.1% TO 1120 (0.4%)
Annualized Habitat Units Lost	1.5	1.5	0 TO 259	136	93	[5]	232 TO 491
Mitigation Lands Required (acres)	5	5	0 TO 830	440	300	—	750 TO 1580
*SOCIAL EFFECTS:							
Relocations (farmsteads, residences, etc)	5	0	0 TO 115 (88) [6]	0	1	0	6 TO 121 (88) [6]
Lands Required (acres)	250	95	0 TO 2200	780	530	14,450	16,105 TO 18,305
*FLOOD DAMAGE REDUCTION EFF. [7]	35%	(NOT SEPARABLE)	(NOT SEPARABLE)	(NOT SEPARABLE)	(NOT SEPARABLE)	(NOT SEPARABLE)	49% TO 55%

NOTES:

[1] Design Flow In Channel, Or Maximum Release From Reservoir During The Design Flood In Cubic Feet per Second.
[2] RRN Indicates Benefits Which May Accrue Along The Red River Of The North.
[3] Annual Benefits Minus Annualized Costs.
[4] Percentage Figure In Parenthesis Indicates The Percent Of Habitat Type Affected In The Lower Sheyenne Basin (Griggs County Through Cass County).
[5] No Estimates Are Currently Available.
[6] Number In Parenthesis Indicates The Number Of Cabins Included In The Relocations.
[7] Percent Of Total Sheyenne River Flood Damages Reduced.

Plan D-2 - Plan D-2 is summarized in table M-13. Plan D-2, although similar to plan D-1, includes no storage of flood flows. Plan D-2 is a diversion-based plan with the levees and diversion around West Fargo/ Riverside (M-30 to M-24) as its major component. The location of the plan components is shown on Plate M-4.

Table M-13

SUMMARY OF PLAN D-2

DATA PARAMETERS \ COMPONENTS OF PLAN D-2	LEVEES AND DIVERSION AT WEST FARGO (M-30 to M-20)	DIVERSION FROM HORACE TO WEST FARGO (M-42 to M-30)	REVISED MANAGEMENT OF BALDHILL DAM	RELOCATION OF FREQUENTLY FLOODED RESIDENCES AT VALLEY CITY	RING LEVEES AT FARMSTEADS AND RESIDENCES FROM KINDRED TO HORACE AND FROM WEST FARGO TO MOUTH	TOTAL
***PERTINENT DATA:**						
Flood Control Storage (acre-feet)	—	—	14,000	—	—	BALDHILL: 14,000
Design Discharge (cfs) [a]	3400	1700	2,500	—	—	—
Level of Protection	1%	—	—	10% [b]	1%	—
***ECONOMICS:**						
COSTS						
First Cost ($ million)	$14 to $17	$4 to $7	—	$3 to $45	$3 to $11	$24 to $39.5
Annualized Cost ($1000)	$1,100	$400	—	$280	$500	$2280
BENEFITS						
Flood Control ($1000)						
West Fargo	$2,200	—	YES (2ND PEAK)	—	—	$2,200
Valley City	—	—	YES	$240	—	$270
Agricultural	—	$35	YES (2ND PEAK)	—	—	$40
Other - downstream of West Fargo	—	—	YES (2ND PEAK)	—	YES	$1090
Other - upstream of West Fargo	—	$585	YES (2ND PEAK)	—	YES	
Other - (see note)	—	—	—	—	—	—
SUBTOTAL - Flood Control	$2,200	$620	(NOT SEPARABLE)	$240	PROBABLY > $500	$3600
Potential for other types of Benefit	RECREATION	—	—	—	—	RECREATION
TOTAL BENEFITS ($1000)	$2,200	$620	—	$240	—	$3600
B/C RATIO	2.0	1.5	—	0.9	PROBABLY > 1.0	1.6
NET BENEFITS ($1000) [c]	$1,100	$220	—	$ -40	—	$1320
***ENVIRONMENTAL EFFECTS:**						
Woodlands Affected (acres)	2	2	—	—	[e]	4 (0.01%)
Wetlands Affected (acres) [d]	18 (0.1%)	0	[e]	—	[e]	18 (0.1%)
Grasslands Affected (acres) [d]	54 (0.06%)	32 (0.04%)	—	—	[e]	86 (0.1%)
Annualized Habitat Units Lost	1.5	1.5	[e]	—	[e]	3
Mitigation Lands Required (acres)	5	5	—	—	[e]	10
***SOCIAL EFFECTS:**						
Relocations (farmsteads, residences, etc.)	5	0	—	87	—	92
Lands Required (acres)	250	90	—	10	[e]	350
***FLOOD DAMAGE REDUCTION EFF.** [f]	35%	10%	(NOT SEPARABLE)	4%	8%	57%

NOTES:

[a] Design Flow In Channel, Or Maximum Release From Reservoir During The Design Flood In Cubic Feet Per Second.

[b] Residences To Be Relocated Would Have First Floor Flooding Caused By Occurrence Of 10% Chance Flood.

[c] Annual Benefits Minus Annualized Costs.

[d] Percentage Figures In Parenthesis Indicates The Percent Of Habitat Type Affected In The Lower Sheyenne Basin (Griggs County Through Cass County).

[e] No Estimates Currently Available.

[f] Percent Of Total Sheyenne River Flood Damages Reduced.

The diversion from Horace to West Fargo (M-42 to M-30) is another component of plan D-2. This diversion was selected over the diversions to the Wild Rice River because it would reduce damages during both Sheyenne River flood peaks in the area between Horace and West Fargo, whereas the Wild Rice diversions would not. Together, these two components would reduce flood damages along the Sheyenne River from Horace (M-42) downstream to below the West Fargo/Riverside area (M-24) for both peaks.

Individual ring levees at farmsteads and residences were included in the plan to reduce flood damages along the Sheyenne River at areas downstream of West Fargo/Riverside and between Horace and Kindred. The ring levees would reduce damages during both peaks and provide good localized protection from up to the 1-percent chance flood.

To provide some additional reduction of flood damages at Valley City, revised management of Baldhill Dam was included. The revised management alternative would affect second peak flooding along the Sheyenne River from Baldhill Dam to the Red River. Because revised management of Baldhill Dam would not provide a high degree of flood protection at Valley City, relocation of frequently flooded residences at Valley City was included to provide positive protection for those most affected by flooding in Valley City. The relocation at Valley City would include those residences that would have first-floor flooding from a 10-percent chance flood.

In summary, plan D-2 addresses first and second peak flooding along the Sheyenne River from Kindred to the mouth with the levees and diversion around West Fargo/Riverside (M-30 to M-24), diversion from Horace to West Fargo (M-42 to M-30), and the ring levees at farmsteads and residences from Kindred to Horace and from West Fargo to the mouth. Second

peak flooding is addressed with the revised management of Baldhill Dam The relocation of frequently flooded residences at Valley City would enhance the plan by protecting residences from up to the 10-percent chance flood at Valley City. As shown in table M-13 (at October 1978 price levels and evaluation conditions), the total cost of plan D-2 would range from $24 to $39.5 million, with an average annual cost of $2.28 million. The annual benefits provided by this plan are estimated at $3.6 million, resulting in a benefit-cost ratio of 1.6 and net benefits of $1.32 million. As in plan D-1, most of these benefits are attributable to the levees and diversion around West Fargo/Riverside alternative. The relocation alternative at Valley City would involve the largest number of relocations, while the levees and diversion alternative would require acquisition of the largest number of acres of land for implementation.

Plan D-3 - Plan D-3 is summarized in table M-14. It is based on use of the levees and diversion at West Fargo/Riverside supplemented by flood storage at Baldhill Dam and other smaller structures. A significant increase in the storage at Baldhill Dam would help control the second peak along the entire Sheyenne River and provide a high degree of protection at Valley City. This increase would provide major flood stage reductions to areas outside the West Fargo/Riverside area. A 5- to 15-foot raise would increase flood control storage at Baldhill Dam 30,000 to 150,000 acre-feet, effectively doubling or quadrupling the storage now available. The location of the plan components is shown in Plate M-5.

Tributary dams T-150 and T-158 were added because of their relative effectiveness in reducing the first peak, especially in the areas downstream of Kindred. Although the dams would provide some reductions of large floods, they would be most effective for floods in the 5- to 10-percent chance range. They would also have some beneficial effects along the Red River downstream from the mouth of the Sheyenne River.

To supplement the reduction of the first peak by tributary dams along the Sheyenne and Red Rivers, the plan includes the restoring of drained wetlands, increases in the storage capacity of existing wetlands, and/or control structures on legal drains from Baldhill Dam to Kindred. The wetland alternative addresses the more frequent floods in the same manner as the tributary dams.

In summary, plan D-3 addresses first peak flooding along the Sheyenne River from the mouth to near Lisbon with the levees and diversion around West Fargo/Riverside (M-30 to M-24), tributary dams T-150 and T-158, and wetland restoration. Second peak flooding along the Sheyenne River from Baldhill Dam to the mouth is addressed with the levees and diversion around West Fargo/Riverside (M-30 to M-24) and the 5- to 15-foot raise of Baldhill Dam. As shown in table M-14 (at October 1978 price levels and evaluation conditions), the total cost would range from $28.5 to $57.5 million and the average annual cost from $410,000 to $590,000. The total benefits would range from $3.33 to $3.76 million, resulting in a benefit-cost ratio between 1.0 and 1.3. Most of the benefits are attributable to the levees and diversion. Recreation benefits could be added by including recreational development with the levees and diversion and tributary dams. The Baldhill Dam raise would involve the largest number of relocations, and the wetland alternative would require acquisition of the largest number of acres of land.

Table M-14

SUMMARY OF PLAN D-3

DATA PARAMETERS \ COMPONENTS OF PLAN D-3	LEVEES AND DIVERSION AT WEST FARGO (M-30 to M-24)	RAISE OF BALDHILL DAM 5 to 15 FEET	RESTORATION OF DRAINED WETLANDS, INCREASE STORAGE CAPACITY OF EXISTING WETLANDS and/or PUT CONTROL STRUCTURES ON LEGAL DRAINS FROM BALDHILL DAM TO KINDRED	TRIBUTARY DAMS: T-150 DEAD COLT CREEK (multi-purpose)	TRIBUTARY DAMS: T-158 TIMBER COULEE	TOTAL
***PERTINENT DATA:**						BALDHILL: 30,000 TO 105,000 T-150: 5,000 T-158: 5,700
Flood Control Storage (acre-feet)	—	30,000 TO 105,000	YES	5000	5700	
Design Discharge (cfs) [1]	3400	2,500	—	—	—	—
Level of Protection []	1%	—	—	—	—	—
***ECONOMICS:**						
COSTS						
First Cost ($ million)	$14-$17	$7 TO $30	$6 TO $7	$0.8 TO $1.8	$0.7 TO $1.7	$28.5 TO $575
Annualized Cost ($1000)	$1,100	$800 TO $2,000	$480	$120	$110	$2610 TO $3810
BENEFITS						
Flood Control ($1000)						
West Fargo	$2,200	YES (2ND PEAK)	YES (1ST PEAK)	YES (1ST PEAK)	YES (1ST PEAK)	$2300 TO $2400
Valley City	—	$410 TO $590	—	0	0	$410 TO $590
Agricultural	—	YES (2ND PEAK)	YES (1ST PEAK)	YES (1ST PEAK)	YES (1ST PEAK)	$170
Other - downstream of West Fargo	—	YES (2ND PEAK)	YES (1ST PEAK)	YES (1ST PEAK)	YES (1ST PEAK)	$400 TO $550
Other - upstream of West Fargo	—	YES (2ND PEAK)	YES (1ST PEAK)	YES (1ST PEAK)	YES (1ST PEAK)	
Other - (see note) [2]	—	—	RRN	RRN	RRN	RRN (< $50)
SUBTOTAL - Flood Control	$2,200	MORE THAN $410	—	—	—	$3330 TO $3760
Potential for other types of Benefit	RECREATION	—	FISH & WILDLIFE	WATER SUPPLY, RECREATION	WATER SUPPLY, RECREATION	RECREATION, WATER SUPPLY, FISH & WILDLIFE
TOTAL BENEFITS ($1000)	$2,200	(NOT SEPARABLE)	(NOT SEPARABLE)	(NOT SEPARABLE)	(NOT SEPARABLE)	$3330 TO $3760
B/C RATIO	2.0	—	—	—	—	1.0 TO 1.3
NET BENEFITS ($1000) [3]	$1,100	—	—	—	—	$50 TO $720
***ENVIRONMENTAL EFFECTS:**						
Woodlands Affected (acres) [4]	2	185 TO 555	[5]	40	30	257 (1%) TO 627 (2.2%)
Wetlands Affected (acres) [4]	18	260 TO 785	[5]	—	—	278 (0.6%) TO 803 (1.7%)
Grasslands Affected (acres) [4]	54	594 TO 1783	[5]	260	200	1108 (0.4%) TO 2297 (0.8%)
Annualized Habitat Units Lost	1.5	259 TO 778	[5]	136	93	489.5 TO 1008.5
Mitigation Lands Required (acres)	5	830 TO 2500	—	440	300	1575 TO 3245
***SOCIAL EFFECTS:**						
Relocations (farmsteads, residences, etc.)	5	115 (88) [6] TO 192 (137) [6]	0	0	1	121 (88) [6] TO 198 (137) [6]
Lands Required (acres)	250	2200 TO 6700	14,450	780	530	18,210 TO 22,710
***FLOOD DAMAGE REDUCTION EFF.** [7]	35%	(NOT SEPARABLE)	(NOT SEPARABLE)	(NOT SEPARABLE)	(NOT SEPARABLE)	53% TO 59%

NOTES:

[1] Design Flow In Channel, Or Maximum Release From Reservoir During The Design Flood In Cubic Feet per Second.
[2] RRN Indicates Benefits Which May Accrue Along The Red River Of The North.
[3] Annual Benefits Minus Annualized Costs.
[4] Percentage Figure In Parenthesis Indicates The Per Cent Of Habitat Type Affected In The Lower Sheyenne River Basin (Griggs County Through Cass County).
[5] No Estimates Are Currently Available.
[6] Number In Parenthesis Indicates The Number Of Cabins Included In The Relocations.
[7] Percent Of Total Sheyenne River Flood Damages Reduced.

Plan D-4 - Plan D-4 is summarized in table M-15. It is similar to the other levee and diversion based plans except that it incorporates channelization from Kindred to West Fargo and ring levees at individual farmsteads and residences from West Fargo to the mouth. The levees and diversion around West Fargo/Riverside (M-30 to M-24) are again the major components, reducing flood damages for both peaks of the Sheyenne River floods as well as the backwater effects from the Maple, Rush, and Red Rivers. The channelization of the Sheyenne River would involve channel enlargement and/or channel straightening and would address both the first and second peaks. Tributary dams T-150 and T-158 were added because of their first peak reductions. The location of plan components is shown on plate M-6.

Table M-15

SUMMARY OF PLAN D-4

DATA PARAMETERS \ COMPONENTS OF PLAN D-4	LEVEES AND DIVERSION AT WEST FARGO (M-30 to M-24)	CHANNELIZATION OF SHEYENNE RIVER FROM HORACE TO WEST FARGO	REVISED MANAGEMENT OF BALDHILL DAM	TRIBUTARY DAMS: T-150 DEAD COLT CREEK (multi-purpose)	TRIBUTARY DAMS: T-158 TIMBER COULEE	RESTORATION OF DRAINED WETLANDS, INCREASE UPLAND CAPACITY OF EXISTING WETLANDS, AND/OR PUT CONTROL STRUCTURES ON LEGAL DRAINS FROM BALDHILL DAM TO HORACE	RING LEVEES AT FARMSTEADS AND RESIDENCES FROM WEST FARGO TO MOUTH	TOTAL
*PERTINENT DATA:								
Flood Control Storage (acre-feet)	—	—	14,000	5,000	5,700	—	—	BALDHILL: 14,000; T-150: 5,000; T-158: 5,700
Design Discharge (cfs) [a]	3400	3100	2,500	—	—	—	—	—
Level of Protection [b]	1%	—	—	—	—	—	1%	—
*ECONOMICS:								
COSTS								
First Cost ($ million)	$14 to $17	$14 to $28	—	$0.8 to $1.8	$0.7 to $1.7	$6 to $7	$2.5 to $9	$38 to $64.5
Annualized Cost ($1000)	$1,100	$1,600	—	$120	$480	$480	$350	$3760
BENEFITS								
Flood Control ($1000)								
West Fargo	$2,200	—	YES (2nd PEAK)	YES (1st PEAK)	YES (1st PEAK)	YES (1st PEAK)	—	$2300
Valley City	—	0	$60	0	0	—	—	$60
Agricultural	—	YES	YES (2nd PEAK)	YES (1st PEAK)	YES (1st PEAK)	YES (1st PEAK)	—	$170
Other - downstream of West Fargo	—	—	YES (2nd PEAK)	YES (1st PEAK)	YES (1st PEAK)	YES (1st PEAK)	YES	$1400 (downstream and upstream together)
Other - upstream of West Fargo	—	YES	YES (2nd PEAK)	YES (1st PEAK)	YES (1st PEAK)	YES (1st PEAK)	—	
Other - (see note) [c]	—	—	—	RRN	RRN	RRN	—	RRN (<$550)
SUBTOTAL - Flood Control	$2,200	—	—	—	—	—	PROBABLY > $350	$3980
Potential for other types of Benefit	RECREATION	— (NOT SEPARABLE)	— (NOT SEPARABLE)	WATER SUPPLY, RECREATION (NOT SEPARABLE)	WATER SUPPLY, RECREATION (NOT SEPARABLE)	FISH & WILDLIFE (NOT SEPARABLE)	—	WATER SUPPLY, FISH & WILDLIFE, RECREATION
TOTAL BENEFITS ($1000)	$2,200	—	—	—	—	—	—	$3980
B/C RATIO	2.0	—	—	—	—	—	PROBABLY > 1.0	1.1
NET BENEFITS ($1000) [d]	$1,100	—	—	—	—	—	—	$220
*ENVIRONMENTAL EFFECTS:								
Woodlands Affected (acres) [e]	2	552	—	40	30	[e]	[e]	624 (2.2%)
Wetlands Affected (acres) [e]	18	—	—	—	—	[e]	[e]	18 (0.1%)
Grasslands Affected (acres) [e]	54	—	—	260	200	[e]	[e]	514 (0.2%)
Annualized Habitat Units Lost	1.5	560	—	136	93	[e]	[e]	790.5
Mitigation Lands Required (acres)	5	1806	—	440	200	—	[e]	2551
*SOCIAL EFFECTS:								
Relocations (farmsteads, residences, etc.)	5	0	—	0	1	0	—	6
Lands Required (acres)	250	2650	—	780	530	14,450	[e]	18,660
*FLOOD DAMAGE REDUCTION EFF. [f]	35%	(NOT SEPARABLE)	(NOT SEPARABLE)	(NOT SEPARABLE)	(NOT SEPARABLE)	(NOT SEPARABLE)	6%	62%

NOTES:
[a] Design Flow In Channel, Or Maximum Release From Reservoir During The Design Flood In Cubic Feet Per Second.
[b] RRN Indicates Benefits Which May Accrue Along The Red River Of The North.
[c] Annual Benefits Minus Annualized Costs.
[d] Percentage Figure In Parenthesis Indicates The Percent Of Habitat Type Affected In The Lower Sheyenne Basin (Griggs County Through Cass County).
[e] No Estimates Are Currently Available.
[f] Percent Of Total Sheyenne River Flood Damages Reduced.

To supplement the tributary dams, the wetland alternative was added to reduce first peak flood damage along the Sheyenne and Red Rivers. The wetland alternative involves restoring drained wetlands, increasing the storage capacity of existing wetlands, and/or putting control structures on legal drains from Baldhill Dam to Kindred. This alternative would address the more frequent floods in the same manner as the tributary dams.

The ring levees at farmsteads and residences from West Fargo to the mouth were added to reduce damages for both peaks in this downstream area. Although the wetlands and tributary dams would reduce flood levels in areas north of West Fargo, the channelization would tend to worsen flood problems in the same area. The flood threat in areas north of West Fargo would still be substantial even though the net effect would be reduced. Thus, the ring levees could provide a degree of flood protection in this area.

Revised management of Baldhill Dam was added to provide some additional flood level reductions at Valley City and Lisbon.

As shown in table M-15, the total cost would range from $38 to $64.5 million. The average annual cost would be $3.76 million. Total benefits are $3.98 million, resulting in a benefit-cost ratio of 1.1. Most of the benefits are attributable to the levees and diversion around West Fargo/Riverside. Some recreation benefits may be added by including recreation development at the levee and diversion and the tributary dams. The wetland alternative would require the acquisition of the largest number of acres of land.

Plan K-1 - Pertinent information for plan K-1 is summarized in table M-16. Plan K-1 involves near site capacity flood control development at the Kindred site. With 360,000 acre-feet of flood control at the Kindred site, flood damages can be reduced for the first and second

peaks along the Sheyenne River from the damsite to the mouth. Flood damage can also be reduced along the Red River downstream from the mouth of the Sheyenne River. The location of plan components is shown on Plate M-7.

Table M-16 SUMMARY OF PLAN K-1

COMPONENTS OF PLAN K-1 / DATA PARAMETERS	KINDRED DAM (NEAR-SIZE CAPACITY)	REVISED MANAGEMENT OF BALDHILL DAM	TOTAL
*PERTINENT DATA:			
Flood Control Storage (acre-feet)	360,000	14,000	374,000
Design Discharge (cfs) [1]	2,000	2,500	—
Level of Protection []	> 1%	—	—
*ECONOMICS:			
COSTS			
First Cost ($ million)	$45 to $55	—	$45 - $55
Annualized Cost ($1000)	$4,000	—	$4000
BENEFITS			
Flood Control ($1000)			
West Fargo	$2,200	YES (2ND PEAK)	$2,200
Valley City	0	≈ $60	$60
Agricultural	YES	YES (2ND PEAK)	$500
Other - downstream of West Fargo	YES	YES (2ND PEAK)	} $1540
Other - upstream of West Fargo	YES	YES (2ND PEAK)	
Other - (see note) [2]	RRN (< $200)	—	RRN (< $200)
SUBTOTAL - Flood Control	—	—	$4,500
Potential for other types of Benefit	WATER SUPPLY, RECREATION	—	WATER SUPPLY, RECREATION
TOTAL BENEFITS ($1000)	(NOT SEPARABLE)	(NOT SEPARABLE)	$4,500
B/C RATIO	—	—	1.1
NET BENEFITS ($1000) [3]	—	—	$500
*ENVIRONMENTAL EFFECTS:			
Woodlands Affected (acres) [4]	5370 (19.1%)	—	5370 (19.1%)
Wetlands Affected (acres) [4]	380 (0.8%)	[5]	380 (0.8%)
Grasslands Affected (acres) [4]	6790 (2.2%)	—	6790 (2.2%)
Annualized Habitat Units Lost	3565	[5]	3565
Mitigation Lands Required (acres)	16,610	—	16,610
*SOCIAL EFFECTS:			
Relocations (farmsteads, residences, etc.)	62 [6]	—	62 [6]
Lands Required (acres)	36,000	—	36,000
*FLOOD DAMAGE REDUCTION EFF. [7]	(NOT SEPARABLE)	(NOT SEPARABLE)	68%

NOTES:

[1] MAXIMUM RELEASE FROM RESERVOIR DURING DESIGN FLOOD IN CUBIC FEET PER SECOND.
[2] RRN INDICATES BENEFITS WHICH MAY ACCRUE ALONG THE RED RIVER OF THE NORTH.
[3] ANNUAL BENEFITS MINUS ANNUALIZED COSTS.
[4] PERCENTAGE FIGURE IN PARENTHESIS INDICATES THE PERCENT OF HABITAT TYPE AFFECTED IN THE LOWER SHEYENNE BASIN (GRIGGS COUNTY THROUGH CASS COUNTY).
[5] NO ESTIMATES ARE CURRENTLY AVAILABLE.
[6] DOES NOT INCLUDE RELOCATIONS RESULTING FROM ACQUISITION OF MITIGATION LANDS.
[7] PERCENT OF TOTAL SHEYENNE RIVER FLOOD DAMAGES REDUCED.

Revised operation of Baldhill Dam was considered to allow for greater drawdowns in the spring to provide additional flood protection at Valley City and Lisbon. As shown in table M-16 (at October 1978 price levels and evaluation conditions), the total first cost would range from $45 to $55 million. The average annual cost would be $4.0 million. The total benefits would be $4.5 million, resulting in a benefit-cost ratio of 1.1. Almost all the benefits are attributable to Kindred Dam. Although this plan calls for a dry dam used exclusively for flood control storage, a small permanent pool could be added without reducing the flood control effectiveness. With a permanent pool, the potential for recreation and water supply benefits exists.

Plan K-2 - A summary of pertinent information for plan K-2 is contained in table M-17. Plan K-2 is based on a reduced-size flood control reservoir at the Kindred site. The storage capacity of 180,000 acre-feet would reduce flood damage for both the first and second peaks along the Sheyenne River from the damsite to the mouth. Flood damage could also be reduced along the Red River; however, most of the benefits would accrue downstream from the mouth of the Sheyenne River. The location of plan components is shown on Plate M-8.

Table M-17

SUMMARY OF PLAN K-2

DATA PARAMETERS / COMPONENTS OF PLAN K-2	KINDRED DAM (REDUCED SIZE)	RAISE OF BALDHILL DAM (5 to 15 FEET)	DIVERSION FROM THE MAPLE RIVER TO THE RRN	TOTAL
*PERTINENT DATA:				
Flood Control Storage (acre-feet)	180,000	30,000 TO 105,000	—	KINDRED: 180,000 BALDHILL: 30,000 TO 105,000
Design Discharge (cfs) [1]	2,000	2,500	3000 [2]	—
Level of Protection [1]	1%	—	—	—
*ECONOMICS:				
COSTS				
First Cost ($ million)	$35 TO $45	$7 TO $30	$23 TO $28	$65 TO $103
Annualized Cost ($1000)	$3,000	$800 TO $2000	$2,000	$5,800 TO $7,000
BENEFITS				
Flood Control ($1000)				
West Fargo	YES	YES (2ND PEAK)	YES	$2,000 TO $2,400
Valley City	0	$410 TO $590	—	$410 TO $590
Agricultural	YES	YES (2ND PEAK)	YES	$450
Other - downstream of West Fargo	YES	YES (2ND PEAK)	YES	$1000 TO $1800
Other - upstream of West Fargo	YES	YES (2ND PEAK)	—	
Other - (see note) [3]	RRN	—	—	RRN (< $200)
SUBTOTAL - Flood Control	(NOT SEPARABLE)	MORE THAN $410	(NOT SEPARABLE)	$4060 TO $5440
Potential for other types of Benefit	WATER SUPPLY, RECREATION	—	—	WATER SUPPLY, RECREATION
TOTAL BENEFITS ($1000)	—	(NOT SEPARABLE)	—	$4060 TO $5440
B/C RATIO	—	—	—	0.7 TO 0.8
NET BENEFITS ($1000) [4]	—	—	—	-$1740 TO -$1560
*ENVIRONMENTAL EFFECTS:				
Woodlands Affected (acres) [5]	3705	185 TO 555	6	3896 (13.9%) TO 4266 (15.2%)
Wetlands Affected (acres) [5]	249	260 TO 785	9	518 (1.1%) TO 1043 (2.2%)
Grasslands Affected (acres) [5]	4673	594 TO 1783	157	5424 (1.8%) TO 6613 (2.2%)
Annualized Habitat Units Lost	2749	259 TO 778	2.5	3010.5 TO 3529.5
Mitigation Lands Required (acres)	12,789	830 TO 2500	8	13,627 TO 15,297
*SOCIAL EFFECTS:				
Relocations (farmsteads, residences, etc.)	35 [6]	115 (88) [7] TO 192 (137) [7]	1	151 (88) [6,7] TO 228 (137) [6,7]
Lands Required (acres)	25,000	2200 TO 6700	1280	28,480 TO 32,980
*FLOOD DAMAGE REDUCTION EFF. [8]	(NOT SEPARABLE)	(NOT SEPARABLE)	(NOT SEPARABLE)	61% TO 83%

NOTES:

[1] DESIGN FLOW IN CHANNEL, OR MAXIMUM RELEASE FROM RESERVOIR DURING THE DESIGN FLOOD IN CUBIC FEET PER SECOND.
[2] MAXIMUM FLOW TO BE DIVERTED FROM THE MAPLE RIVER.
[3] RRN INDICATES BENEFITS WHICH MAY ACCRUE ALONG THE RED RIVER OF THE NORTH.
[4] ANNUAL BENEFITS MINUS ANNUALIZED COSTS.
[5] PERCENTAGE FIGURE IN PARENTHESIS INDICATES THE PERCENT OF HABITAT TYPE AFFECTED IN THE LOWER SHEYENNE BASIN (GRIGGS COUNTY THROUGH CASS COUNTY).
[6] DOES NOT INCLUDE RELOCATIONS RESULTING FROM ACQUISITION OF MITIGATION LANDS.
[7] NUMBER IN PARENTHESIS INDICATES NUMBER OF CABINS INCLUDED IN THE RELOCATIONS.
[8] PERCENT OF TOTAL SHEYENNE RIVER FLOOD DAMAGES REDUCED.

Because of the reduced storage capacity, the magnitude and volume of the second peak coming from above Baldhill Dam become increasingly important. Therefore, a 5- to 15-foot raise of Baldhill Dam was added to provide an additional 30,000 to 105,000 acre-feet of flood control storage. This raise would reduce flood damages caused by the second peak of Sheyenne River floods from Baldhill Dam to the Red River. This magnitude of raise would be very effective at Valley City.

A diversion from the Maple to the Red River was added to further reduce flood damages along the Sheyenne River in the area downstream of West Fargo. This alternative would divert up to 3,000 cfs of Maple River flood flows away from the Sheyenne River to the Red River, thus reducing flood stages along the Sheyenne River from the mouth of the Maple River to the Red River. The diversion would also reduce the effects on flood levels in the West Fargo/Riverside area caused by backwater from the Maple and Red Rivers.

As shown in table M-17 (at October 1978 price levels and evaluation conditions), the total first cost would range from $65 to $103 million. The average annual cost would range from $5.8 to $7.0 million. The total benefits would range from $4.06 to $5.44 million, resulting in a benefit-cost ratio from 0.7 to 0.8. Most of the benefits are attributable to the Kindred Dam as well as the potential for recreation and water supply development. The Kindred Dam would require acquisition of the largest number of acres of land. The Baldhill Dam raise would involve the largest number of relocations.

Plan K-3 - Plan K-3 is summarized in table M-18. It involves a reduced-size flood control storage capacity of 180,000 acre-feet at Kindred Dam, as described in plan K-2. However, a diversion to the Wild Rice River and revised management of Baldhill Dam to alleviate flood damage along the Sheyenne River are also included. The location of plan components is shown on Plate M-9.

Table M-18

SUMMARY OF PLAN K-3

DATA PARAMETERS / COMPONENTS OF PLAN K-3	KINDRED DAM (reduced size)	DIVERSION TO WILD RICE RIVER (M-65)	RURAL LEVEES FROM KINDRED DAM TO DIVERSION CHANNEL AT M-65	REVISED MANAGEMENT OF BALDHILL DAM	TOTAL
*PERTINENT DATA:					
Flood Control Storage (acre-feet)	180,000	—	—	14,000	KINDRED: 180,000 BALDHILL: 14,000
Design Discharge (cfs) [1]	4,000 [2]	2000	4000	2,500	—
Level of Protection [1]	1%	—	—	—	—
*ECONOMICS:					
COSTS					
First Cost ($ million)	$35 to $45	$6 to $8	$1	—	$42 to $54
Annualized Cost ($1000)	$3000	$510	$80	—	$3590
BENEFITS					
Flood Control ($1000)					
West Fargo	YES	YES (2ND PEAK)	[3]	YES (2ND PEAK)	$2,200
Valley City	—	—	—	$60	$60
Agricultural	YES	YES (2ND PEAK)	[3]	YES (2ND PEAK)	$400
Other - downstream of West Fargo	YES	YES (2ND PEAK)	[3]	YES (2ND PEAK)	$1440
Other - upstream of West Fargo	YES	YES (2ND PEAK)	[3]	YES (2ND PEAK)	
Other - (see note) [4]	RRN	—	—	—	RRN (<$200)
SUBTOTAL - Flood Control	—	—	—	—	$4300
Potential for other types of Benefit	WATER SUPPLY, RECREATION	—	—	—	WATER SUPPLY, RECREATION
TOTAL BENEFITS ($1000)	(NOT SEPARABLE)	(NOT SEPARABLE)	(NOT SEPARABLE)	(NOT SEPARABLE)	$4300
B/C RATIO	—	—	—	—	1.2
NET BENEFITS ($1000) [5]	—	—	—	—	$710
*ENVIRONMENTAL EFFECTS:					
Woodlands Affected (acres) [6]	3705	7	[7]	—	3712 (13%)
Wetlands Affected (acres) [6]	249	—	[7]	—	249 (0.5%)
Grasslands Affected (acres) [6]	4673	12	[7]	—	4685 (1.6%)
Annualized Habitat Units Lost	2749	1.5	[7]	—	2750.5
Mitigation Lands Required (acres)	12,789	5	[7]	—	12,794
*SOCIAL EFFECTS:					
Relocations (farmsteads, residences, etc.)	32 [8]	1	—	—	33 [8]
Lands Required (acres)	25,000	210	50	—	25,260
*FLOOD DAMAGE REDUCTION EFF. [9]	(NOT SEPARABLE)	(NOT SEPARABLE)	(NOT SEPARABLE)	(NOT SEPARABLE)	65%

NOTES:

[1] DESIGN FLOW IN CHANNEL, OR MAXIMUM RELEASE FROM RESERVOIR DURING THE DESIGN FLOOD IN CUBIC FEET PER SECOND.
[2] BASED ON USING THE DIVERSION TO THE WILD RICE RIVER AT FLOW OF 2000 CUBIC FEET PER SECOND.
[3] NEED TO CONTAIN HIGHER RELEASES FROM THE DAM TO THE DIVERSION CHANNEL.
[4] RRN INDICATES BENEFITS WHICH MAY ACCRUE ALONG THE RED RIVER OF THE NORTH.
[5] ANNUAL BENEFITS MINUS ANNUALIZED COSTS.
[6] PERCENTAGE FIGURE IN PARENTHESIS INDICATES THE PER CENT OF HABITAT TYPE AFFECTED IN THE LOWER SHEYENNE BASIN (GRIGGS COUNTY THROUGH CASS COUNTY).
[7] NO ESTIMATES ARE CURRENTLY AVAILABLE.
[8] DOES NOT INCLUDE RELOCATIONS RESULTING FROM ACQUISITION OF MITIGATION LANDS.
[9] PERCENT OF TOTAL SHEYENNE RIVER FLOOD DAMAGES REDUCED.

The storage capacity at the Kindred site would reduce flood damages for both the first and second peaks along the Sheyenne River. It would also reduce flood damage along the Red River. However, since the magnitude and volume of the second peak would significantly reduce the effectiveness of a reduced-size Kindred Dam, the diversion to the Wild Rice River (M-65) with connecting levees from the dam to the inlet of the diversion was added to allow for more versatile operation of Kindred Dam. This combination of Kindred Dam, rural levees, and diversion channel allows the Baldhill Dam alternative to be limited to revised management to provide protection mainly for Valley City. Also, this combination would allow higher releases from Kindred Dam on the recession side of the Red River flood peak.

As shown in table M-18 (at October 1978 price levels and evaluation conditions), the total first cost would range from $42 to $54 million. The average annual cost would be $3.59 million. The total benefits would be $4.3 million, resulting in a benefit-cost ratio of 1.2. With the addition of a permanent pool, recreation and water supply benefits could be achieved at Kindred without any noticeable effect on the flood control effectiveness. The Kindred Dam would require a large number of acres of land and a large number of relocations.

Plan K-3 offers significant advantages over plans K-1 and K-2 by requiring fewer acres of land and relocations and significant reductions in the duration of floodwater storage. It would still provide about the same level of protection. The reduction in storage duration is not reflected in the mitigation land requirement in table M-18; incorporating these reduced durations should reduce the mitigation land required. The releases from Kindred Dam and operation of the diversion would be coordinated so that peak stages on the Red River would not be increased over natural conditions.

COMPARISON OF PLANS AND PLAN SELECTION

The seven stage 2 plans were compared for their relative contributions to reducing flood damages, ability to improve the economic and social well-being of the Nation and the region, potential for adverse social and environmental effects, potential for addition of other purposes to meet other needs in the basin, and potential for precluding the meeting of other objectives. A summary (at October 1978 price levels and evaluation conditions) of the relative merits of the seven plans is given in table M-19.

Identification of the plans or plan components that should be studied further started by looking at the levee and diversion ("D") plans and identifying which had the greatest probability of being implemented and/or delivering the greatest amount of desirable outputs. A similar rationale was used in comparing the Kindred Dam ("K") plans to identify which would be most desirable. As a result of the comparison/selection process, plans D-3, D-4, K-1, and K-2 were recommended to be dropped and plans D-1, D-2, and K-3 were recommended for further study. The rationale for keeping or dropping the plans was based on the merits of the individual plans as well as comparison with other plans. A summary of the plans and the rationale for their elimination from or selection for further study as presented in the stage 2 report is summarized in table M-20.

Table M-19

SUMMARY OF PRELIMINARY PLANS, SHEYENNE RIVER, NORTH DAKOTA

FLOOD DAMAGE REDUCTION PLANS / DATA PARAMETERS	PLAN D-1	PLAN D-2	PLAN D-3	PLAN D-4	PLAN K-1	PLAN K-2	PLAN K-3
	- Levees & Diversion @ West Fargo - Diversion to Wild Rice (M-34) - Revised Management and/or Raise of Baldhill Dam about 5 feet - Tributary Dams (T-150 & T-158) - Wetlands (Baldhill to Kindred)	Levees & Diversion @ West Fargo Diversion from Horace to West Fargo Revised Management of Baldhill Dam Relocation of Residences @ Valley City Ring Levees @ Farmsteads & Residences (Kindred to Horace & West Fargo to North)	- Levees & Diversion @ West Fargo - Raise of Baldhill Dam (5-15 feet) - Wetlands (Baldhill to Kindred) - Tributary Dams (T-150 & T-158)	- Levees & Diversion @ West Fargo - Channelization (Kindred to West Fargo) - Revised Management of Baldhill Dam - Tributary Dams (T-150 & T-158) - Wetlands (Baldhill to Kindred) - Ring Levees @ Farmsteads & Residences (North of West Fargo)	- Kindred Dam (Max Site Capacity) - Revised Management of Baldhill Dam	- Kindred Dam (Reduced Size) - Raise of Baldhill Dam (5-15½ feet) - Diversion of Maple River to [illegible]	- Kindred Dam (Reduced Size) - Diversion to Wild Rice (M-49) - Rural Levees from Kindred Dam to Mouth of Diversion - Revised Management of Baldhill Dam
***PERTINENT DATA:**							
Flood Control Storage (acre-feet)	BALDHILL: 14,000 to 49,000 T-150: 6,000 T-158: 6,700	BALDHILL: 14,000	BALDHILL: 30,000 to 106,000 T-150: 6,000 T-158: 5,700	BALDHILL: 14,000 T-150: 5,000 T-158: 5,700	KINDRED: 360,000 BALDHILL: 14,000	KINDRED: 180,000 BALDHILL: 30,000 to 106,000	KINDRED: 180,000 BALDHILL: 14,000
Design Discharge (cfs) []	—	—	—	—	—	—	—
Level of Protection []	—	—	—	—	—	—	—
***ECONOMICS:**							
COSTS							
First Cost ($ million)	$24.5 to $44.5	$24 to $39.5	$28.5 to $57.5	$38 to $64.5	$45-$55	$65 to $103	$42 to $54
Annualized Cost ($1000)	$2100 to $2900	$2280	$2610 to $3810	$3760	$4,000	$5,800 to $7000	$3590
BENEFITS							
Flood Control ($1000)							
West Fargo	$2300	$2,200	$2300 to $2400	$2300	$2,200	$2,000 to $2400	$2,2[illegible]
Valley City	$60 to $440	$270	$410 to $590	$60	$60	$410 to $590	$60
Agricultural	$200	$40	$170	$170	$500	$450	$400
Other - downstream of West Fargo	$500	$1090	$400 to $550	$1,400	$1,540	$1,000 to $1,800	$1490
Other - upstream of West Fargo							
Other - (see note)[1]	RRN (<$50)	—	RRN (<$50)	RRN (<$50)	RRN (<$200)	RRN (<$200)	RRN (<$200)
SUBTOTAL - Flood Control	$3110 to $3490	$3600	$3330 to $3760	$3980	$4500	$4060 to $5440	$4300
Potential for other types of Benefit	RECREATION, FISH & WILDLIFE, WATER SUPPLY	RECREATION	RECREATION, FISH & WILDLIFE, WATER SUPPLY	RECREATION, FISH & WILDLIFE, WATER SUPPLY	RECREATION, WATER SUPPLY	RECREATION, WATER SUPPLY	RECREATION, WATER SUPPLY
TOTAL BENEFITS ($1000)	$3110 to $3490	$3600	$3330 to $3760	$3980	$4500	$4060 to $5440	$4300
B/C RATIO	1.2 to 1.5	1.6	1.0 to 1.3	1.1	1.1	0.7 to 0.8	1.2
NET BENEFITS ($1000) [2]	$590 to $1010	$1320	-$50 to +$720	$220	$500	-$1740 to -$1560	$710
***ENVIRONMENTAL EFFECTS:**							
Woodlands Affected (acres)	77 to 262	4	257 to 627	624	5370	3896 to 4266	3,712
Wetlands Affected (acres)	18 to 278	18	278 to 803	18	380	518 to 1043	249
Grasslands Affected (acres)	526 to 1,120	86	1,108 to 2,297	514	6,790	5424 to 6613	4685
Annualized Habitat Units Lost	232 to 491	3	489.5 to 1008.5	790.5	3,565	3010.5 to 3529.5	2750.5
Mitigation Lands Required (acres)	750 to 1,580	10	1,575 to 3,245	2551	16,610	13,627 to 15,297	12,794
***SOCIAL EFFECTS:**							
Relocations (farmsteads, residences, etc.)	6 to 121 (88)[3]	92	121 (88)[3] to 198 (137)[3]	6[4]	62[4]	151 (88)[3,4] to 288 (137)[3,4]	33[4]
Lands Required (acres)	16,105 to 18,305	350	18,210 to 22,710	18,660	36,000	28,480 to 32,980	25,260
***FLOOD DAMAGE REDUCTION EFF.** [5]	49% to 55%	57%	53% to 59%	62%	68%	61% to 83%	65%

NOTES:

[1] RRN INDICATES BENEFITS WHICH MAY ACCRUE ALONG THE RED RIVER OF THE NORTH.
[2] ANNUAL BENEFITS MINUS ANNUALIZED COSTS.
[3] NUMBER IN PARENTHESIS INDICATES THE NUMBER OF CABINS INCLUDED IN THE RELOCATIONS.
[4] DOES NOT INCLUDE RELOCATIONS RESULTING FROM ACQUISITION OF FISH AND WILDLIFE MITIGATION LANDS. RELOCATION ESTIMATES FOR MITIGATION AREAS RANGE FROM D-4 (15-25); K-1 (40-60); K-2 (30-60), K-3 (20-40) THIS DOES NOT INCLUDE ANY RELOCATIONS RESULTING FROM UNECONOMIC FARM REMNANTS FOLLOWING LAND ACQUISITION.
[5] EFFECTIVENESS IS REPRESENTED AS PERCENT OF TOTAL SHEYENNE RIVER FLOOD DAMAGES REDUCED.

Table M-20 - Summary of recommendations in Stage 2 Working Papers Report

Plan	Summary rationale
Plans dropped	
D-3	The major raise of Baldhill Dam (greater than 5 feet) as the principal means of controlling the second peak in the lower basin appears to have greater negative aspects than benefits. With the large social impacts, it may be difficult to implement.
D-4	The channelization of the lower Sheyenne River as the main secondary element would have major environmental impacts. Because it could worsen downstream flooding, it generally has a lack of support.
K-1	A full-sized Kindred Dam, which is the only component of the plan, would have major adverse environmental and relocation impacts. Release rates would be fairly restricted because of the limited channel capacity of the Sheyenne River, requiring retention of the floodwaters in the reservoir for long periods of time. Opposition to this plan is significant.
K-2	A reduced-size Kindred Dam and a major raise of Baldhill Dam bring significant opposition to two components of this plan. Major durations of retention of floodwaters would still cause potential major adverse environmental effects.
Plans warranting further study	
D-1	This plan would provide widespread benefits with relatively minor social and environmental impacts. It would also provide opportunities for inclusion of other purposes without precluding other planning objectives.
D-2	This plan would provide widespread benefits. Although several components of this plan are generally supported, they may be difficult to implement. Flood damage reduction can be provided in a cost-effective manner with minor adverse environmental effects and net social benefits.
K-3	This plan would provide a high degree of flood protection over a wide area. The diversion would allow higher releases from the reservoir, thus reducing the environmental impacts of the storage by shortening the period of retention.

PLANS TO BE DROPPED

On the basis of conclusions reached in stage 2, the following plans were recommended to be dropped from further study in the Stage 2 Working Papers Report.

Plan D-3

The concept of coupling the levees and diversion with a major raise of Baldhill Dam and other features would rely on the additional flood control storage in Baldhill Dam to provide protection from the second peak along the lower Sheyenne River from Kindred to West Fargo and to provide a higher degree of protection at Valley City. Valley City residents have not expressed interest in having a high degree of flood protection. They believe an improved level of flood protection is necessary, but not such a high level that it causes major adverse social impacts in their area. Raises of Baldhill Dam greater than 5 feet would cause large numbers of relocations, much land acquisition, and high costs. As the level of the proposed raise of Baldhill Dam increases, the level of opposition increases and little additional support can be found among those who would benefit. Comparable protection of the Kindred to West Fargo area could be provided by plans D-1, D-2, and K-3 with a greater distributive equity, placing the adverse impacts more upon the beneficiaries. The net benefits for higher raises of Baldhill Dam decrease to the point where raises greater than 15 feet become uneconomical from the standpoint of flood protection. This plan is recommended to be dropped in favor of plans D-1, D-2, and K-3.

Plan D-4

The concept of using channelization of the lower Sheyenne River from Kindred to West Fargo to provide protection for this reach and extend the area of protection upstream of the basic levee and diversion component at West Fargo/Riverside would have many disadvantages. The channelization would provide protection in this reach from both the first and second peaks; however, in doing so it would also tend to keep more flow in the river channel, which could worsen downstream flood conditions. Tributary dams T-150 and T-158 and the restoration of wetlands would be used to increase the level of protection in the Kindred to West Fargo reach and reduce flood

stages downstream of West Fargo, including offsetting any increases induced by the channelization. One of the major disadvantages would be the environmental losses. Downstream of Kindred, the only continuous tracts of woodland are found immediately adjacent to the river. Channelization would disturb a significant portion of this riparian woodland. This plan is recommended to be dropped in favor of plans D-1, D-2, and K-3.

Plan K-1

The full-size Kindred Dam, which would essentially develop the site to its maximum potential for construction of a dam and reservoir, would have major adverse social and environmental consequences. A major portion of the woodland habitat of the lower basin would be affected. A segment of the Sheyenne River having potential as a scenic or recreational river would be affected. A large number of relocations would be required and 36,000 acres of land would be acquired. In spite of the high level and wide dispersion of the benefits, this plan is recommended to be eliminated in favor of plans D-1, D-2, and K-3.

Plan K-2

Reducing flood control storage at the Kindred Dam site by one-half and constructing a major raise of Baldhill Dam to offset this reduction would make the environmental and land acquisition impacts of this plan less than those of plan K-1. However, a greater number of families would be affected by relocations. The diversion of the Maple River to the Red River would help increase the level of protection in the lower reaches of the Sheyenne River downstream of West Fargo, but it would not lessen the impacts of the other two components. The major raise of Baldhill Dam appears to have little support among those who would benefit. This plan is recommended to be dropped in favor of plans D-1, D-2, and K-3.

PLANS WARRANTING FURTHER STUDY

Of the plans considered in stage 2, the following were recommended in the Stage 2 Working Papers Report for further study.

Plan D-1

This plan would reduce flood damages in all reaches of the Sheyenne River, protect to high levels at West Fargo/Riverside, and protect to a moderate degree in the other areas. The storage provided by the tributary dams, wetland storage, and modification of Baldhill Dam would detain the floodwaters, releasing them at a later time. The diversion to the Wild Rice River would use the extra capacity of the Red River to provide relief along the Sheyenne River, which has very limited capacity. Although the river stages along the Wild Rice and Red Rivers would be kept at high levels slightly longer than normal, this increase in duration is not expected to cause any major adverse impacts. This plan would have benefits in excess of costs and relatively minor adverse social and environmental impacts. Therefore, this plan is recommended for further consideration.

Plan D-2

This plan would provide widespread benefits without the use of storage. Its components are basically local protection works. Flood flows would not be noticeably altered, except to a small degree, by the revised management of Baldhill Dam and the diversion from Horace to West Fargo. Major economic damages and social disruptions would be prevented by this plan. However, the large flood-prone areas north of West Fargo, from Kindred to Horace, and upstream of Kindred would still be flooded. This plan would have relatively few adverse social and environmental effects. Most of the adverse effects would be incurred by the plan's beneficiaries. The relocation of structures from a portion of the Valley City floodplain would have the greatest social impacts of the plan components. This plan

offers many advantages over the other plans; however, it also has some potential drawbacks from local sponsor viewpoints; namely, impacts are located in the benefit area. This plan is recommended for further consideration.

Plan K-3

This plan would provide a high degree of flood protection in areas downstream of Kindred Dam, and its benefits would exceed its costs. Its adverse environmental and social impacts would be less than those of plans K-1 and K-2; however, they would still be significant. Over 33 relocations and over 20,000 acres of land acquisition would be required. The plan would reduce flood damages along the Red River and would offer opportunities to add water-based recreation and water supply purposes. However, the adverse effects on the environmental setting would be major, and the effects on the scenic potential of this reach of river must be considered in the final decision on this plan. This plan is recommended for further consideration.

STAGE 2 WORKING PAPERS REPORT

CONCLUSIONS PRESENTED IN THE STAGE 2 REPORT

The following conclusions were presented in the Stage 2 Working Papers Report which was distributed for agency and public review and comment in 1980.

1. Joint-coordinated actions by Federal, State, and local agencies - For any plan to be effective in resolving the problems associated with flooding in the basin, the effort to address the issues and solutions must be fully coordinated among Federal, State, and local agencies. The magnitude and extent of the problem require the commitment of resources that exceed the capability of the State and local interests to analyze the problems and implement solutions to these problems. Although Federal agencies can provide the resources to analyze problems and implement

some elements of the possible solutions, they do not have the authority to implement many of the elements needed to make any effective long-range plan function. Commitments are required by all three levels to resolve the issues. Failure by any one of the levels will result in either complete failure of the plan or, at best, implementation of an incomplete plan.

2. Essential elements of any plan - Several elements of any plan being developed for the basin must be considered as basic components to prevent future increases of flood damage potential and ensure the viability of any comprehensive flood damage reduction plan. These components include existence and enforcement of floodplain zoning and regulations, availability of flood insurance in flood-prone areas, control of private levee construction, and continuation and enforcement of existing drainage laws.

The floodplain regulations and zoning should be used to ensure that future construction in flood-prone areas is consistent with true flood risk and will not require corrective action. Flood insurance should be available for existing structures in flood-prone areas to assist in minimizing losses. Future construction in flood-prone areas should also have flood insurance available at the full and true cost of such insurance. A control system should be established for private levee construction that would minimize the adverse effects of levees on flood levels on other properties. The regulation of drainage must be enforced to ensure that any future drainage does not worsen flood conditions. Floodplain regulations, drainage regulation, and control of private levees require involvement and implementation by State and local interests.

3. Any comprehensive plan should include either the Kindred Dam or local protection in the West Fargo area - In addition to measures taken to ensure that future flood damage potential is not worsened, a comprehensive plan must significantly reduce flood damage potential of existing flood-prone structures. A comprehensive plan for the Sheyenne River basin

should include either the Kindred Dam or local protection at West Fargo/Riverside as the key component of the plan. The West Fargo/ Riverside area, the major urban center, sustains the majority of potential flood damages and is subject to flooding from two peaks on the Sheyenne River and the backwater effects of the Maple, Rush, and Red Rivers. Upstream reservoir storage would require a dam at the closest point to the damage to be able to control both peaks and during the first peak to be able essentially to reduce the flow to zero. This reservoir location would be near the Kindred Dam site. If major upstream reservoir storage is not used, some form of levee protection must be used at West Fargo/Riverside. The most cost-effective and least disruptive levee plan identified consists of the combination of levees and diversion channel around West Fargo/Riverside. Other components could be added to provide a plan that reduces flood damages over larger areas of the basin.

4. Many potential combinations of alternatives have been considered - The seven comprehensive plans for flood damage reduction presented in the stage 2 report represent the most effective combinations of alternatives to reduce flood damages in the basin. Plans D-1, D-2, and K-3 appear to warrant further consideration. The components are somewhat interchangeable between plans and some may be added or deleted.

5. Opportunities to meet other water management purposes and needs could be considered in conjunction with the plans carried for further evaluation - At this point, meeting other needs does not appear to be an overriding factor in plan selection. Plan selection would be based primarily on the capability of the plan to reduce flood damages. Project features should be added to any plan, where appropriate, to meet other objectives (such as water supply, water quality, and recreation).

6. The selection of the plan to be recommended for implementation should be based on the overall merit of the plan - Whereas the opposition for a plan will be presented and publicly discussed, the support for a plan may or may not be publicly presented. The adverse aspects of a plan must be presented, addressed, and minimized to the extent practicable during the decision-making process.

7. Non-Federal interests would be able to more effectively implement their portions of an overall water management plan if they had jurisdiction over the entire watershed - Water resource districts, which are generally organized on a county basis, have little incentive to consider upstream or downstream interests outside of their area of jurisdiction in their decisions. Although the potential for adverse effects downstream may be considered, potential projects that are beneficial to other areas are rarely considered. A watershed approach to water management planning, decisions, and implementation would result in better water management for the entire area.

8. For each remaining plan, local sponsors will need to be identified and contacted regarding their interest in the plan and/or plan component.

9. The views of Federal and State agencies, the Lower Sheyenne River Citizens Committee, and other interests are instrumental in the plan selection process - Successful implementation of a selected plan will depend on Federal, State, and local interests reaching an agreement on the results of this study.

PUBLIC AND AGENCY COMMENTS

The main report of the Stage 2 Working Papers Report was distributed to Canadian, Federal, and State agencies; water management districts; counties; cities; media; and interested organizations and individuals. The technical appendixes were provided to Canadian, Federal, and State agencies; members of the Lower Sheyenne River Citizens Committee; and, upon request, to other interested organizations and individuals.

Letters of comment were received from nine Federal agencies, six State agencies, five cities, eight water management districts and counties, eight organizations, and five individuals. Table M-21 summarizes these comments. The table indicates whether the comments included a specific recommendation to keep or drop any of the three plans recommended for further study. It also summarizes the remarks.

TABLE M-21 Summary of comments on the stage 2 report

COMMENTING PARTY	PLAN			REMARKS/OTHER COMMENTS
	D1	D2	K3	
FEDERAL AGENCIES				
Department of Agriculture Forest Service	N	K	D	Need more information about K-3 to assess impacts on Sheyenne National Grasslands.
Department of Agriculture Soil Conservation Service (Bismarck)	N	N	N	SCS participation in the implementation of tributary dams requires analysis by Principles and Standards. Must have local sponsorship.
Department of Commerce National Weather Service	N	N	N	No significant issues, resources, or impacts have been omitted.
Department of Health and Human Services	N	N	N	Any proposed flood control project should be an overall benefit.
Department of Interior Fish and Wildlife Service (Bismarck)	D	K	D	Plan D-2 with wetland restoration added is favored.
Department of Interior National Park Service	N	N	N	No National parks affected; no comment.
Department of Interior Water and Power Resources Service	N	N	N	Water quality discussions need more documentation.
Environmental Protection Agency	N	N	D	Favor water quality improvement of Lake Ashtabula. No water quality storage needed at Kindred Dam or Baldhill Dam.
Federal Energy Regulatory Commission	N	N	N	Raise of Baldhill Dam and/or Kindred Dam would provide small hydroelectric potential. Development of this hydroelectric potential does not appear economically feasible.

K - KEEP FOR FURTHER STUDY
D - DROP FROM FURTHER STUDY
N - NO RECOMMENDATION STATED

COMMENTING PARTY	PLAN			REMARKS/OTHER COMMENTS
	D1	D2	K3	
STATE AGENCIES				
North Dakota Forest Service	N	K	N	Plan D-2 has the least impact on woodlands.
North Dakota Game and Fish Department	K	K	D	Favor some type of diversion plan. Add restoration of drained wetlands to areas above Baldhill Dam.
North Dakota State Highway Department	N	N	N	Impacts of transportation facilities from local through State systems need further study.
North Dakota State Water Commission	K	K	K	Further studies should be conducted on plans D-1, D-2, and K-3. Consideration should also be given to a combination of plans D-1 and D-2, in which small upland water retention dams would be included. Specific views on components of the plans will be provided after more detail is available.
State Historical Society of North Dakota	N	N	N	Evaluations are provided based on standpoint that the area of total land disturbance by each plan is an indication of cultural resources affected.
Minnesota Pollution Control Agency	N	N	N	No comment at this time.
CITIES				
City of Casselton	N	N	N	No comment at this time on flood control plans. More concerned about potential future drought conditions.
City of Grand Forks	D	D	K	Prefer original authorized Kindred Dam project; however, would favor plan K-3 with addition of a small conservation pool.

K - KEEP FOR FURTHER STUDY
D - DROP FROM FURTHER STUDY
N - NO RECOMMENDATION STATED

2

Table M-21 (cont)

Table M-21 (cont)

COMMENTING PARTY	PLAN			REMARKS/OTHER COMMENTS
	D1	D2	K3	
CITIES (continued)				
City of Valley City	N	N	N	Do not support relocation of flood-prone structures within Valley City. Favor revised management and/or raise up to 5 feet of Baldhill Dam.
City of West Fargo	K	K	K	Plans D-1 and D-2 appear to address mainly West Fargo's problems and do not solve the problems downstream. Costs of plans D-1 and D-2 appear to be too low.
WATER MANAGEMENT DISTRICTS				
Barnes County Water Management District (Russell McKay)	K	K	N	Favor the installation of small holding dams, diversion of the Wild Rice into the Red River, and diversion ditches and dikes around West Fargo.
Barnes County (Lester Abraham)	N	N	N	Do not favor any raise of Baldhill Dam. Favor small dams and revised management of Baldhill Dam. All drainage should be controlled drainage.
Red River Joint Water Management Board	K	K	D	Favor addition of small upland water retention dams as part of plans D-1 and D-2. Do not recommend plan K-3 for any further studies.
Richland County Water Management District (Jorgen Haugen)	N	K	D	D-2 is favored with some changes.
Rush River Water Management District (Ken McIntyre)	N	K	D	Plan D-2 is favored with some modifications including diversions to the Red River of the North at miles 35 and 19. Favor up to 5-foot raise of Baldhill Dam and support construction of small retention dams.
Ransom County Water Management District	K	K	D	Plan D-1 or D-2, with modifications, would be supported. Raises of Baldhill Dam should be dropped. Relocation of frequently flooded residences in Valley City should be dropped. Timber Coulee Dam should be dropped. Keep Dead Colt Creek Dam.

K - KEEP FOR FURTHER STUDY
D - DROP FROM FURTHER STUDY
N - NO RECOMMENDATION STATED

3

COMMENTING PARTY	PLAN D1	PLAN D2	PLAN K3	REMARKS/OTHER COMMENTS
WATER MANAGEMENT DISTRICTS (cont.)				
Southeast Cass Water Management District	K	K	K	Favor protection for larger floods. If a diversion plan is to be viable, consideration should be given to substantial reclamation of wetlands, control drainage and diking, and active program of ring levees. Many concerns on diversion plans must be answered before plan is acceptable.
ORGANIZATIONS				
Lower Sheyenne River Citizens Committee	K	K	D	No new drains without controls and reassess existing drainage for controls. Monitor and regulate any private levee construction which might affect river levels at Horace and downstream points.
North Dakota Farm Bureau	N	N	D	Favor a series of small dry dams throughout the basin.
North Dakota Township Officers Association	K	K	D	Favor a series of dikes, channelizing and small retention dams.
Pleasant Township (Mr. Jerome Nipstad)	D	K	D	Against any diversion to Wild Rice River.
Richland County Farm Bureau	N	N	D	Strongly oppose Kindred Dam.
Sheyenne Valley Association	K	K	D	D-2 is favored with no relocations at Valley City.
Sheyenne Valley Grazing Association	K	K	D	D-2 is favored with some modifications.

K - KEEP FOR FURTHER STUDY
D - DROP FROM FURTHER STUDY
N - NO RECOMMENDATION STATED

4

Table M-21 (cont)

COMMENTING PARTY	PLAN D1	D2	K3	REMARKS/OTHER COMMENTS
OTHER				
"The Forum" Fargo-Moorhead Newspaper	D	D	K	Strong support for upstream storage, including use of the Kindred site.
Mr. Greg Doffin	K	K	D	Favor ring levees for areas downstream of West Fargo as well as between West Fargo and Horace.
Michael L. Gregg (University of North Dakota)	N	N	N	Concerns and interests relate to identification and protection of important cultural resources lying in areas where landscape modifications will be made to implement a plan.
Mr. Larry Richard and Mr. George Richard	D	N	D	Against any diversion to Wild Rice River.
Mr. R. Joseph Sether	D	D	K	Favor the upstream storage of flood waters. Not in favor of diversions.

K - KEEP FOR FURTHER STUDY
D - DROP FROM FURTHER STUDY
N - NO RECOMMENDATION STATED

5

Table M-21 (cont)

A summary of the comments received on the pertinent plans, individual plan components, and purposes are presented in the following paragraphs.

Plan D-1

Interests along the routes of the diversions to the Wild Rice River (Pleasant Township, Mr. Larry Richard, and Mr. George Richard) oppose any diversion to the Wild Rice River.

Interests along the Red River (city of Grand Forks and the editor of the Fargo-Moorhead Forum) believe the diversions to the Wild Rice and Red Rivers and the other diversions do not contribute to the solution of the flooding problems of the Red River and should be dropped in favor of the storage alternatives.

The U.S. Fish and Wildlife Service expressed concern over the adverse impacts of the storage elements of plan D-1.

There was general support for keeping plan D-1 for further consideration, although there was also concern regarding the actual viability and/or implementability of several of the plan's components. The favorable comments on plan D-1 generally supported the concept of the plan, but suggested that modifications be considered in further studies.

Plan D-2

Although only three of the letters received favored dropping the diversions and other components of plan D-2 (the city of Grand Forks, the Forum, and Mr. R, Joseph Sether), many expressed concern about the viability of the plan. Most of the letters supported keeping plan D-2 or a modification for further evaluation.

Plan K-3

Most of the comments received on this plan recommended dropping it from further construction. These views were expressed from the U.S. Forest

Service, U.S. Fish and Wildlife Service, Environmental Protection Agency, North Dakota Game and Fish Department, Red River Joint Water Management Board, Lower Sheyenne River Citizens Committee, and many others. The major concerns were the large acreages of land required and the effects on the relocated residents and the local tax base, woodland and wildlife in the project area, and groundwater levels.

Recommendations that plan K-3 should be kept for further study came from the North Dakota State Water Commission, city of Grand Forks, city of West Fargo, Southeast Cass Water Management District, Fargo-Moorhead Forum, and Mr. R. Joseph Sether.

Other Plans

The North Dakota State Water Commission and the Red River Joint Water Management Board requested consideration of a plan that would combine the features of plans D-1 and D-2 with small upland water retention dams. Comments from other agencies and interests also suggested the modification of plans D-1 and D-2.

Components of the Plans

Baldhill Dam - Valley City preferred revised management of Baldhill Dam and a maximum 5-foot raise to reduce potential flood damages in the city. Barnes County, however, opposed any raises that would require acquisition of lands. Other interests also commented on the raise.

Tributary Dam - Timber Coulee - The city of Lisbon, Ransom County, and the Ransom County Water Management District all recommended dropping the Timber Coulee site from further consideration or changing its location.

Tributary Dam - Dead Colt Creek - The city of Lisbon, Ransom County, and the Ransom County Water management District indicated that the Dead Colt Creek dam should be built as a multiple-purpose project including storage for flood control.

Relocation of Frequently Flooded Structures at Valley City - Valley City does not support the relocation of flood-prone structures. No favorable responses were received concerning the relocations at Valley City.

Wetlands - The U.S. Fish and Wildlife Service indicated it would cooperate in a wetland restoration/wetland size increase program if adequate consideration were given to wildlife resources. The Bureau of Reclamation indicated the possibility of acquiring and restoring drained wetlands in the basin as part of a wildlife mitigation plan for the Garrison Diversion Unit. These restored wetlands could also provide flood control storage. The North Dakota Game and Fish Department believes the drainage area above Baldhill Dam should also be considered.

Control of Drainage - The Lower Sheyenne River Citizens Committee passed a resolution asking the North Dakota State Water Commission to ensure that all future drainage projects be controlled so as to not increase downstream flood problems and that existing drainage projects be reassessed to determine if additional controls are needed. The North Dakota State Water Commission stated that Section 61-02-02 of the North Dakota Century Code requires that drainage of a watershed of 80 acres or more must have a permit from the State Engineer and the appropriate water management district and that all drainage in the Red River basin is of statewide significance requiring final approval by the State Engineer. Enforcement is often difficult; however, reorganization of the water management districts could strengthen enforcement.

Water management districts and others also discussed the need for control of drainage in the basin.

Control of Private Levee Construction - The North Dakota State Water Commission commented that Section 61-16-15 of the North Dakota Century Code requires permits for levees that contain more than 12.5 acre-feet of water (this would include all levees along the Sheyenne River). This regulation is not easy to enforce. However, the water management districts and the water commission are making efforts toward stricter enforcement. The ability of the water management districts and the Water Commission to provide effective control of these private levees is essential to development of any levee and diversion plan for the lower Sheyenne River.

Water Resource Management and Related Purposes

Flood Damage Reduction - When commented on, flooding and flood damages along the lower Sheyenne River were generally recognized as a major problem. The Soil Conservation Service commented that the statements of the flooding problem should be clarified.

Water Supply - Existing and future water supply needs as discussed in the stage 2 report were addressed only by the Bureau of Reclamation and Valley City. The bureau indicated that more than 60,000 acres of potentially irrigable land is in the area of the Kindred reservoir site and that the potential water needs of this land should be recognized in the analysis of future water needs. Valley City indicated its concern with adequate water storage for its future needs if the management of Baldhill Dam were to be revised without proper consideration for potential water shortages during severe droughts.

Water Quality - The Bureau of Reclamation indicated its concern over the adequacy of the water quality information in the report. The Environmental Protection Agency indicated no foreseeable need for storage at either the Kindred Dam site or Baldhill Dam to improve water quality. The EPA indicates that opportunities to improve the water quality in Lake Ashtabula should be considered.

Recreation - The city of Grand Forks commented that a small permanent pool should be considered in plan K-3 to improve recreation potential. No one else commented on the recreation needs or potentials of the study area.

Hydroelectric Power - The Federal Energy Regulatory Commission provided information on the potential for hydropower at the Kindred Dam site and Baldhill Dam. The Commission's analysis showed small potential for the development of hydropower; it does not appear to be economically feasible to develop the power potential at these sites.

Fish and Wildlife - The U.S. Forest Service indicated there are opportunities for improving wildlife habitat on the Sheyenne National Grasslands, but no specific proposals are being considered for implementation. The Fish and Wildlife Service, Environmental Protection Agency, and North Dakota Game and Fish Department indicated that the potential for the restoration of drained wetlands should be investigated further with the possibility of improving wildlife habitat.

Cultural Resources - The State Historical Society of North Dakota and Michael L. Gregg, University of North Dakota, commented that additional information should be gathered in potential project areas to ensure that proper consideration is given to cultural resources when any project is developed.

CONCLUSIONS REACHED AFTER PUBLIC AND AGENCY REVIEW

The comments received on the Stage 2 Working Papers Report were reviewed and the following conclusions were made concerning the analysis of alternatives for flood damage reduction and the incorporation of other purposes that would be accomplished in stage 3.

1. The three plans recommended for further evaluation, D-1, D-2, and K-3, are not widely supported without some modification of components. The levee and flood diversion oriented plans are widely supported by interests who would be potentially adversely affected by the Kindred Dam plan. The Kindred Dam plan is supported for further study primarily by the principal beneficiaries along the Sheyenne River. The residents of the floodplain downstream of Kindred are concerned about the effectiveness of the levee and diversion plans.

2. Few comments discussed the inclusion of other purposes in the flood damage reduction plans. No comments suggested that the plan selection process should be based on the potential of the plans to benefit other purposes. Rather, all indications were that plan selection should be based on the relative contributions of the plans to flood damage reduction. Although potentially irrigable lands were mentioned by the U.S. Bureau of Reclamation, none of the property owners, counties, or water resource district personnel have expressed any interest in developing these lands. No identified needs for irrigation water can be shown at present for which plan formulation would be affected. Whereas storage for water quality improvement was one of the purposes of the authorized Kindred Lake project, no justification could be found at this time for including storage for water quality as a project purpose in any of the alternatives.

3. None of the potential non-Federal sponsors for the various plans expressed a strong interest in fulfilling the requirements of local sponsorship of any specific plan component. The general support for the plans by the North Dakota State Water Commission indicates that the overall sponsorship of a plan would probably come from the Water Commission. However, support for the components of the plan would also have to come from the cities, counties, and water resource districts most directly benefited by the plan. Indications of this support would have to be sought from these interests.

4. A flood damage reduction plan that combines components of plans D-1 and D-2 should be developed, evaluated, and coordinated with the potential local sponsors to work toward a fully implementable plan. The following components should be considered for inclusion in the combination plan:

a. Levees and diversion at West Fargo/Riverside.

b. Floodway/diversion from Horace to West Fargo.

c. Raise of Baldhill Dam (5 feet or less).

d. Dead Colt Creek tributary dam (multiple-purpose).

e. Restoration of drained wetlands/increasing size of existing wetlands.

f. Ring levees at farmsteads and residences.

STAGE 3 EVALUATION

GENERAL

The alternatives considered in further detail during stage 3 were evaluated as components of plans consistent with the conclusions reached in stage 2 and the regulations of the Office, Chief of Engineers, concerning display and evaluation of alternatives. As additional information was gathered and the plans were developed, several alternatives were dropped. Only those alternatives which were implementable and met the planning guidelines were examined in the final comparison.

ALTERNATIVES AND PLANS DROPPED IN FINAL EVALUATIONS

Kindred Dam/Plan K-3

The Kindred Dam was being retained for further consideration because it was economically justified and, when considered as a part of plan K-3, its environmental and social impacts were less severe than those of other plans which included the Kindred Dam as a component. However, other plans had more favorable economic evaluations and fewer undesirable environmental and social impacts. Also, significant regional opposition existed. This fact, in conjunction with the relative merits and impacts of the other alternatives, led to the conclusion that the Kindred Dam was not implementable.

Many items were considered in the evaluation of the Kindred Dam. These items were significant because of the estimated impacts, perceptions of impacts, and/or the degree of justification provided. Some of the more significant items and their effects on implementability of the Kindred Dam and plan K-3 are discussed in the following paragraphs.

Water Supply Storage -No foreseeable need for additional water supply storage was projected. A permanent pool impounded by a dam near Kindred could provide additional storage for water supply. However, because no

need was identified, no quantifiable benefits can be claimed for water supply. No water supply benefits were claimed in the justification for the authorized multiple-purpose Kindred Lake project. Although droughts such as the one that occurred in 1976-1977 raise significant concerns among area residents about the adequacy of their water sources, unless a drought were severe and of an extended nature, water shortages would not be large. Existing water sources appear adequate for the foreseeable future.

If potentially irrigable lands in the area were irrigated, an additional demand would be imposed on existing water supplies. However, area residents and water management districts have not indicated any need or desire to irrigate these lands.

Even if water shortages were identified, Baldhill Dam could be modified or water could be transferred into the Sheyenne River basin through the Garrison Diversion. Either of these steps is more cost effective than the Kindred Dam in supplying water. Thus, no water supply benefits can be credited to the Kindred Dam.

Water Quality Improvement Storage - Storage for improvement of downstream water quality was a purpose of the authorized Kindred Lake project and accounted for 23 percent of the benefits justifying the project. However, the need for storage for water quality improvement is not projected at this time.

Water quality improvement was incorporated into the Kindred Lake project to alleviate the adverse effects of irrigation return flows on the Sheyenne and Red Rivers. However, the Environmental Protection Agency and Bureau of Reclamation do not consider storage for this purpose necessary. The EPA has responsibility for identifying such a need. A statement from that agency identifying the need is required before benefits could be credited.

Baldhill Dam could be operated to improve downstream water quality. Reservoirs in highly agricultural watersheds often have water quality problems associated with the trapping of nutrients and eutrophication. Any potential water quality benefits would be partly offset by eutrophication.

Thus, no need was identified for storage for water quality improvement and storage was not included in any of the alternatives considered. No benefits for this purpose were credited to any alternative.

Permanent Pool for Recreation - A permanent pool behind Kindred Dam would provide recreation benefits and improve the aesthetics of the project. Because of frequency and duration of floodwater storage, a dry dam operated only for flood control would create a significant area in the lowest portion of the flood pool that would be difficult to keep vegetated. The aesthetics and overall quality of the project could be improved by providing a permanent pool for recreation and other purposes. A small permanent pool that would provide about 1,500 acres of water for recreation but would not reduce the project's flood control effectiveness could easily be incorporated. Several hundred thousand dollars in recreation benefits would be provided annually. The incremental benefit-cost ratio of the recreation pool would range from 1.5 to 2.5. The expressed need for additional water-based recreation was limited. While recreation opportunities could be provided at the Kindred site, the net benefits of adding recreation would be relatively small. Many individuals are concerned that the addition of a permanent pool would alter groundwater levels and vegetation patterns in the area. Thus, although a small permanent pool would be added if the Kindred Dam were constructed, the permanent pool would not significantly change the relative economic evaluation.

Effectiveness in Reducing Flood Stages - The Kindred Dam would be very effective in reducing flood damages along the lower Sheyenne River. Floods at Kindred, Horace, and West Fargo would be reduced almost to nondamaging levels except for very large and extremely infrequent floods. For these large floods, flood levels would often be reduced from the "without project" condition. From West Fargo to the Red River of the North, flood levels would usually be reduced by a couple of feet. However, for some events, the effect might be relatively small, in the range of 1 foot.

Along the Red River, the effectiveness of the Kindred Dam in reducing flood stages would be relatively minor. For example, for the 1979 flood, flood levels at Grand Forks would have been reduced about 0.1 foot. The Sheyenne River floodplain downstream of Kindred already is quite effective at attenuating peak flood contributions to the Red River. Also, much of the Sheyenne River's flood volume contribution occurs after the Red River has peaked. Thus, although Kindred Dam could reduce Red River flood levels, the reduction would be relatively minor. And, because few major reservoir sites exist on tributaries to the Red River, a comprehensive flood damage reduction plan for the Red River main stem does not depend on whether the Kindred Dam is implemented.

Effects on Woodland Habitat from Temporary Inundation by Flood Pool - The largest concentration of woodland habitat in southeastern North Dakota is in the lower Sheyenne River basin in the area that would be affected by the permanent and temporary pools impounded by Kindred Dam. A small permanent pool could cause the permanent loss of 1,000 acres of prime woodland habitat. Temporary floodwater storage could affect an additional 3,000 to 4,000 acres. This effect would be significant for the region. The duration of storage behind the dam under plan K-3 would be significantly shorter than that under plan K-1 or the authorized project. The duration under plan K-3 for a 25-year flood would be minor. However, for a 100-year flood, most of the 3,000 to 4,000 acres of woodland would be flooded for more than 30 days, resulting in an almost total loss of the woodland habitat. Although such an event would be infrequent, its effects are a major concern to those interested in the environmental quality of the area. These effects were accounted for in the determination of the need for a wildlife mitigation plan.

Effectes on the Water Table and Vegetation in Surrounding Areas - One issue at the time of authorization for the Kindred Dam in 1970 was the effect of the project on water table levels and vegetation in areas adjacent to the project. From 1972 through 1974, during the Kindred Lake Restudy, the U.S. Geological Survey examined this issue. The findings of the restudy were that the permanent pool impounded by the Kindred Dam could significantly raise groundwater levels up to 4 miles from the lake (about a 130-square-mile area). Because the water table is very near the surface in this area, major changes in vegetation were predicted. Most people in the region feared that the grazing value of the area would be substantially reduced and that the regional ranching economy would suffer greatly. Because this potential impact was significant and was a significant concern to people in a large area surrounding the project, during Phase I GDM studies, the U.S. Geological Survey evaluated the potential effects in greater detail, improving the quality of its groundwater computer model. The results of this evaluation show that the effects would be substantially less those estimated earlier. The area of significant increase in groundwater level would extend less than 1 mile from the shore of the lake. The area of impact would be only about 12 square miles, less than 10 percent of the previous estimate. For the smaller permanent pool levels considered during Phase I studies, the area of projected increase was even smaller. The magnitude of the increase would also be reduced. The raises would be mostly between 1 and 5 feet and would be in areas where the water table was generally more than 10 feet below the ground surface.

These revised estimates of change in groundwater levels would not be expected to significantly change vegetation patterns in the area. Studies done by North Dakota State University indicated that water table depths of 5 feet or less can be related to vegetation tyoes. Most of the predicted changes in groundwater levels would occur where the vegetation patterns would not be expected to change.

Although the improved estimates of impact showed that effects would be considerably less than previous estimates, the original estimates caused a

tremendous amount of regional concern and opposition to the Kindred Lake project. That concern and opposition has remained in spite of the changed estimates. The perceived impact is greater than the actual impact would be.

Fish and Wildlife Mitigation - Significant acreages of lands were required to mitigate the impacts on fish and wildlife resources that would result from the project. The authorized project would have required acquisition of about 20,000 acres including lands for mitigation. Plan K-3 would have substantially reduced impacts on wildlife, but more mitigation lands would be required because of a change in the mitigation evaluation procedure. Thus, lands required for plan K-3 would total 25,000 acres. Acquisition of large acreages for fish and wildlife purposes is not popular in North Dakota. Proposals for such acquisitions generate much opposition. Even though the Garrison Diversion Unit would bring significant benefits to North Dakota through the irrigation water it would supply, its implementation has been slowed and modified in large part because of issues related to fish and wildlife. Also, the Fish and Wildlife Service has easements on a large number of wetlands in North Dakota. The Service's restrictions on these lands have caused concern throughout the State. Thus, any large acreage identified for acquisition for fish and wildlife purposes would cause concern to and elicit opposition from a large segment of people in North Dakota.

Amount of Private Lands to be Acquired - About 25,000 acres of land would be required for the Kindred Lake project. Most of it is privately owned. The lands that would be acquired are next to the Sheyenne National Grasslands - a 70,000-acre tract administered by the U.S. Forest Service. The addition of 25,000 acres would result in a very large block of federally-owned land in the area. Local opposition to Federal ownership and control of such a large tract of land would be significant.

Diversions to the Wild Rice River

Flood diversion channels from the Sheyenne to the Wild Rice River were considered as components of plans D-1 and K-3 during stage 2. The diversion in plan D-1 would reduce flood flows and stages along the Sheyenne River particularly between Kindred and West Fargo during the second peak. In plan K-3, the diversion would allow release of larger flows from Kindred Dam than would normally be possible.

The diversions were kept for consideration into stage 3. However, when the Kindred Dam was dropped, the diversion as part of plan K-3 was also dropped.

As part of plan D-1, the diversion would have to be supplemented by other measures: tributary dams and flood control storage in existing or drained wetlands between Kindred and Baldhill Dam. The only tributary dam that appears to have economic, environmental, and implementability merit is the dam on Dead Colt Creek. The dam on Timber Coulee, although economically attractive, did not have support for implementation.

Increasing flood storage capacity of wetlands is a controversial subject. Property owners in the watershed are not in favor of preserving more wetland areas. The specific tracts to be used would have to be identified before local support could be determined. Some landowners would be willing to sell their land or grant an easement for preservation of wetland areas so that the low-lying areas can be used to store floodwaters. However, the majority of landowners would not be interested in any type of lease or selling their land. Therefore, this concept would be supported only if most of the landowners whose lands would be acquired were in favor of the proposal. The number of tracts that would have to be acquired is large and would probably be greater than the number of landowners willing to let their lands be used for floodwater storage. Non-Federal sponsorship is very unlikely because of the scope of the alternative if it is to be effective.

Also, the principal benefits of this alternative are fish and wildlife benefits that are not quantifiable in dollars. The flood damage reduction benefits are small when compared to the costs. The likelihood of this alternative being implemented on a large scale is not good. To be implemented, the alternative would have to be implemented on a small scale with the principal justification being fish and wildlife benefits. Each tract would have to be considered on an individual basis.

The Dead Colt Creek Dam by itself would not effectively reduce first peak flooding. Therefore, plan D-1 would have limited effectiveness in reducing flood damages between Kindred and West Fargo. The diversion becomes of limited value because it addresses only the second peak. Thus, the diversions to the Wild Rice River were dropped because a fully implementable plan to effectively reduce basin flood damages in which they could function could not be developed.

FORMULATION OF PLANS

The remaining measures were combined into an array of implementable plans. These plans and their components are listed in table M-22. The plans are labeled no action, environmental quality (EQ), national economic development (NED), nonstructural, and selected plan.

Table M-22 - Summary of the components in the final array of plans[1]

Plan component	Plan: No action[2]	Nonstructural	EQ[3]	NED[4]	Selected
Floodplain regulations	N	N	N	N	N
Flood warning and forecasting	F	F	F	F	F
Flood emergency measures	N	N	N	N	N
Flood insurance	F	F	F	F	F
Debris removal	N	N	-	N	N
Control of wetland drainage	N	N	N	N	N
More stringent control of drainage	-	N	N	-	-
Control of private levee construction	N	N	N	N	N
Flood proofing	-	N	N	-	N
Encourage public control/ownership of riverine lands	-	N	N	-	N
Encourage more land treatment	-	N	N	-	N
Ring levees at farmsteads and residences	-	N[5]	N[5]	N[5]	N[5]
Controlled cattle grazing at Lake Ashtabula	-	-	F	-	F
Subimpoundments at Lake Ashtabula	-	-	F	-	F
Aerators at Lake Ashtabula	-	-	F	-	F
Revised management of Baldhill Dam	-	F	-	-	-
5-foot raise of Baldhill Dam	-	-	-	F	F
Levees and diversion at West Fargo/Riverside	-	F[6]	F[6]	F[6]	F[6]
Flood diversion channel - Horace to West Fargo	-	-	F	F	F
Multiple-purpose dam on Dead C Creek	-	-	-	-	N
Restoration of drained wetlands	-	N	N	-	N
Increasing floodwater storage capacity of existing wetlands	-	N	N	-	N
Postflood relocation at Valley City and Lisbon	-	F	-	-	-

(1) "N" indicates non-Federal interests have primary implementation responsibility; "F" indicates Federal interests have primary implementation responsibility.
(2) Represents the future condition without major Federal action.
(3) Environmental Quality Plan.
(4) National Economic Development Plan.
(5) Principal responsibility for evaluation and implementation would probably be through non-Federal interests; however, Federal participation through the Soil Conservation Service or Corps of Engineers may be possible.
(6) Includes shelterbelts at selected locations and grassed waterways in and along the diversion channel.

No Action Plan

Under the "no action" plan, the future "without project" cndition presented in the main report would occur. Those actions pertinent to the comparison of the no action paln with the other plans include floodplain regulations, flood warning and forecasting, flood emergency measures, flood insurance, debris removal, control of wetland drainage, and control of private levee construction. Floodplain regulations would continue and future development in the floodplain would recognize the flood hazard and be built so that the 1-percent chance flood would cause little or no damage. Flood warning and forecasting would continue and probably be improved as new technology, data collection techniques, and prediction capability are developed. Flood emergency measures taken just preceding or during a flood would be the primary means of preventing damage to existing development. These measures could include constructing emergency levees, moving damageable property above flood levels, evacuating residents of flooded or floodable properties, and other short-term actions. Flood insurance would continue to be available to assist in minimizing the impact of a flood loss on an individual property owner. Debris removal from the river channels and bridge openings would be necessary before and after floods, especially in reaches where the lack of sufficient flow capacity could cause extensive flood damages. The control of wetland drainage would continue. Drainage would be allowed only when it would not worsen flood conditions. Private levee construction would also be controlled. Enforcement of these controls would be difficult, particularly without an overall plan for addressing the flood damage problem, and enforcement would probably not be complete. The no action plan would attempt to reduce flood damages to existing development by short-term action just before and/or during a specific flood. Future development would be essentially flood proofed or flood resistant from most floods. Continuing difficulties, however, would be encountered in the control of drainage and private levee construction. Because drainage and private levees can worsen future floods if not accomplished properly, control of these ewo activities would be crucial to management of future flood problems.

Nonstructural Plan

A plan reducing flood damage using primarily "nonstructural" measures as discussed in ER 1105-2-353 and ER 1165-2-122 and building on the results of the preliminary planning was developed. Valley City and Lisbon are the two locations in the basin where evacuation of flood-prone structure may be an implementable measure, but only under certain conditions. Those areas prone to the most frequent flooding are generally adjacent to the river and represent a significant yet relatively small portion of the city. At Valley City, the evacuation option has marginal economic feasibility; at Lisbon, it clearly lacks economic feasibility. Neither community supports moving from the floodplain, in part because the flood fight efforts for recent floods have been successful and major flood damages have been averted. In the future, however, if flood fight efforts fail and these areas receive substantial damages and if funds were available immediately after the flood to acquire the flooded properties, relocation of residents from much of the Valley City and Lisbon floodplains could be implemented. At West Fargo/Riverside, where the entire community is on flood-prone land, the evacuation alternative is not viable even under the above described conditions for Valley City and Lisbon. The only alternative which can address the objective of reducing flood damages for the existing development in a manner which could be interpreted as "nonstructural" is the levees and flood diversion channel plan around West Fargo. Other features of the "nonstructural" plan listed in table 15 were included to reduce the flood damages in areas outside the three main cities. The control of private levee construction and drainage to prevent the worsening of flooding would be a key element in this plan. Use of existing and drained wetlands in the upland areas to store more floodwaters would help moderate flood peaks. Most of the components of the plan would be for non-Federal implementation. The location of the major features of the nonstructural plan are shown on plate M-10.

Environmental Quality Plan

National environmental policy mandates that important cultural and natural aspects be preserved and that a diverse environment be maintained. Designation of an EQ plan implies that the plan enhances and protects the aesthetic, cultural, and natural diversity of the environment and provides positive contributions to the EQ account. The EQ plan was developed to reduce flood damages and maintain or enhance the environmental resources of the basin, working primarily with the measures carried into the final evaluation stage. The EQ plan components are listed in table 15, with the levees and flood diversion channel at West Fargo/Riverside, the flood diversion channel from Horace to West Fargo, and ring levees at farmsteads and residences providing the nucleus of the plan. The net environmental effects of these three alternatives are about neutral with some minor losses and some minor gains. The other components of the plan are needed either to make the plan effective or provide positive environmental contributions. Measures which add environmental credits to the plan include controlled cattle grazing, subimpoundments, and aerators at Lake Ashtabula; restoration of drained wetlands; increased storage capacity of existing wetlands; encouragement of more land treatment; encouragement of public control/ownership of riverine lands; and control of wetland drainage. Some features which could enhance the environment include planting of extensive shelterbelts and grassy areas of the channels and levees for environmental purposes. Use of the wetland areas of the basin for floodwater storage could also enhance the environment if the operating plans for the management of these areas are developed primarily around waterfowl and wildlife values. Most of the components would be the responsibility of non-Federal interests to implement as part of the overall plan. The location of the major features of the EQ plan are shown on plate M-11.

National Economic Development Plan

The national economic development (NED) plan primarily includes plan components that would increase net economic benefits. The key components for flood damage reduction include the levees and flood diversion channel around West Fargo/Riverside, the flood diversion

channel from Horace to West Fargo, the 5-foot raise of Baldhill Dam, and ring levees and flood proofing at farmsteads and residences. All NED plan components are listed in table M-22. The locations of the major components are shown on plate M-12. All four key components provide net economic benefits. The remaining components - especially control of private levee construction, control of wetland drainage, and floodplain regulations - are essential to making the overall plan work. Another alternative measure - the multiple-purpose Dead Colt Creek Dam - has potential for being included as part of the NED plan, but was not included because no final estimates of benefits were made for this dam operating as a component of the overall plan.

Selected Plan

The components of the selected plan were chosen recognizing the economic, environmental, and implementability aspects of the potential plans and plan components. The levee and flood diversion channel at West Fargo/Riverside plus the flood diversion channel from Horace to West Fargo resulted in as good or better economic considerations for providing flood protection for the developments from Horace through West Fargo as the Kindred Dam plan K-3 or other combinations of plan components with the levee and diversion. The environmental aspects of these two components were very good when compared with other options and there appeared to be general support with little oppostion. While these two components provided good protection for the area from Horace through West Fargo, other areas upstream of Horace and downstream of West Fargo would not receive any protection. Ring levees or other nonstructural flood proofing techniques at individual farmsteads and residences offered the most cost-effective manner to protect these developments. A raise of Baldhill Dam (not exceeding 5 feet) could produce substantial benfits at Valley City and Lisbon and also in areas between Kindred and West Fargo. When considered in conjunction with the upgrading for safety reasons, the cost allocated for flood control was exceeded by the benefits. The multiple-purpose Dead Colt Creek tributary dam and increased floodwater storage capacities of existing and drained upland area wetlands in the reach from Valley City to Kindred were added to reduce flooding from the first peak on the Sheyenne River downstream of Kindred, particularly in the reach from Kindred to Horace and from West Fargo to the mouth of the Sheyenne

River. Floodplain regulations, flood warning and forecasting, control of wetland drainage, and control of private levee construction are essential for an effective plan. Flood emergency measures, flood insurance, debris removal, and flood proofing can provide additional protection when used at appropriate locations and times. The encouragement of public ownership or control of riverine lands; encouragement of more land treatment in upland areas; and controlled cattle grazing, subimpoundments, and aerators at Lake Ashtabula would all provide increases in the EQ account. The control of cattle grazing, subimpoundments, and aerators at Lake Ashtabula could also be accomplished to some extent under a revised management plan for Baldhill Dam, which could be implementable under existing operation and maintenance authorities for the project. Planting of shelterbelts and grasses in selected portions of the diversion channels would help keep the channels operational and less prone to fill with drifted snow as well as providing wildlife benefits. The components of the selected plan are listed in table M-22. Locations of major components are shown on plate M-13.

COMPARISON OF FINAL PLANS

Pertinent information on the final plans is displayed in table M-23. The information presented includes costs, benefits, and impacts for all components of the plans, both Federal and non-Federal, wherever possible. In some cases, however, some of the effects are not quantifiable. For example, in the data presented for the selected plan, the costs and impacts of the wetlands alternative are included; however, quantifiable benefits are extremely difficult to estimate and none are presented in the table even though significant benefits would accrue to the plan as a result of the wetlands alternative.

All plans are economically justifiable and would provide high degrees of flood damage reduction. All plans would improve public health in the area by reducing flooding. The potential of transmitting diseases and contaminating wells during floods would be reduced. The selected plan would benefit the greatest number of people and the largest area. Although the

acquisition impacts seem large for the selected plan, the nature of the actual impact must be considered. Most of the structures to be acquired (about 90 percent) are cabins around Lake Ashtabula which are used primarily as recreational summer lakeshore dwellings and their purchase would not preclude their owners from building on another site around the lake. The new sites might be set back slightly farther from the lakeshore, but the owners would still have their view and access to the lake. Of the large acreage of lands to be acquired, most (about 85 percent) are associated with the wetland alternative. These lands generally have marginal value as cropland and landowners should be relatively receptive to their use for floodwater storage.

The cost-sharing data as presented in table M-23 is based on traditional cost-sharing policy for water resource development projects. However, because the current cost-sharing policies have not yet been established, the distribution of costs between Federal and non-Federal interests as listed should be considered as only a guide. Also, that portion of the cost labeled non-Federal is all costs not to be covered by the Corps of Engineers, including the costs which may be contributed by other Federal agencies. Final estimates and recommendations for cost-sharing and financing arrangements could vary significantly from the information presented in this report.

Table M-23 - Display of pertinent data on final array of plans

Item	Plan				
	No action	Nonstructural	EQ	NED	Selected
Economic					
Costs					
Federal first costs[1] ($ million)	--	14.8	13.1	22.2[9]	22.2[9]
Non-Federal first costs[2] ($ million)	--	38.5	37.9	21.4[9]	39.6[9]
Total first costs ($ million)	--	53.3	51.0	43.6[9]	61.8[9]
Annual costs ($1,000)	--	4,320	4,235	3,700	5,140
Benefits (average annual)					
Flood control ($1,000)					
West Fargo	--	19,551[10]	19,551[10]	19,551	19,551[10][11]
Valley City and Lisbon	--	405[10]	--[10]	1,400	1,400[10][11]
Agricultural	--	42[10]	71[10]	83	83[10][11]
Other	--	4,152[10]	4,600[10]	4,640	4,640[10][11]
Total flood control	--	24,150[10]	24,222[10]	25,674	25,674[10][11]
Recreation ($1,000)	--	some	some	some	some
Fish and wildlife enhancement ($1,000)	--	some	some	---	some
Total benefits ($1,000)	--	24,150	24,222	25,674	25,674[10][11]
Benefit-cost ratio	--	5.6	5.7	6.9	5.0[10][11]
Net benefits ($1,000)	--	19,830	19,987	21,974	20,534[10][11]
Environmental					
Woodlands affected (acres)	--	5	5	250	250
Shelterbelts planted[3] (acres)	--	15	15	285	285
Wetlands affected (acres)	--	20	40	500	500
Wetlands placed under management (acres)	--	18	40-300+	500+	500-800+
Grasslands affected (acres)	--	50	90	250	250
Grasslands placed under management (acres)	--	110	255	350	350
Cropland affected (acres)	--	60	100	350	350
Average annual equivalent loss[4] (habitat units)	--	--	--	142	142
Mitigation lands required (acres)	--	0	0	0-450	0-450
Cultural resources affected[8]	--	No known effects	No known effects	24 sites	24 sites
Social					
Acquisitions (number of homes, etc.)	--	126	3	110[12]	110[12]
Lands required (acres)	--	29,300[13]	29,500[13]	3,300	4,100[13]
Flood damage reduction effectiveness[5]	--	83	84	89	89
Number of persons benefited[6]	--	11,269	11,900	11,750	15,750
Acres of cropland benefited[7]	--	103,000	103,000	58,500	115,000
Residual flood damages	28,939	4,789	4,717	3,265	3,265

(1) Implementation by the St. Paul District, Corps of Engineers, based on traditional cost sharing. The actual cost sharing between Federal and non-Federal interests is subject to significant change. Costs are included for the levees and diversion at West Fargo, the diversion from Horace to West Fargo, the raise of Baldhill Dam, and/or the acquisition of floodplain dwellings as appropriate for each plan.
(2) Includes potential costs of other Federal agencies, as well as non-Federal entities (also based on traditional cost sharing).
(3) Also includes woodlands placed under management.
(4) As measured before mitigation measures are incorporated.
(5) Effectiveness is represented as a percent of total Sheyenne River flood damages reduced.
(6) Estimated number of persons receiving benefits from flood damage reduction measures.
(7) Estimated cropland acreage receiving benefits as a result of reduced frequency of flooding.
(8) Includes only those impacts for sites known to date; intensive survey and testing may identify additional sites.
(9) The costs shown do not include any costs of structural upgrading at Baldhill Dam. Only those costs at Baldhill Dam apportioned to flood control are included.
(10) Does not include benefits for the wetlands alternative.
(11) Does not include benefits for the Dead Colt Creek tributary dam alternative.
(12) Includes about 100 cabins and dwellings on the Lake Ashtabula shoreline.
(13) Does not include any acreage estimate for the wetland alternatives. Potentially, up to 28,900 acres could be acquired for implementation of the wetland alternatives. Although the probability of the full 28,900 acres being acquired is rather unlikely in the foreseeable future, it is possible that some of the wetlands could be implemented in the same timeframe as the other alternatives with the appropriate support from local interests and other Federal agencies.

DESCRIPTION OF THE SELECTED PLAN

The selected plan consists of several types of components: those which would be implemented by the Corps of Engineers; essential components that must be implemented by the non-Federal sponsor; important components of the overall plan that would be implemented by other Federal or non-Federal agencies but are not essential to the functioning of other plan components. The location of the plan components is shown on plate M-13.

PLAN COMPONENTS FOR CORPS OF ENGINEERS IMPLEMENTATION

Three components would be implemented by the Corps of Engineers with the cooperation and participation of non-Federal interests: a raise of Baldhill Dam, levees and a flood diversion channel at West Fargo/Riverside, and a flood diversion channel from Horace to West Fargo.

Raise of Baldhill Dam

The raise of Baldhill Dam would be primarily for the addition of flood control storage to the project. Structural modifications to the existing project are required and would be made to comply with the Dam Safety Assurance Act. The modifications include a 5-foot raise of the design flood pool, about a 5-foot raise of the dam, change in the location of the gated spillway, and change in the operation of the dam during floods. These changes would provide an additional 31,400 acre-feet for floodwater storage over the existng 39,600 acre-feet of dual-use storage now available for major floods. A total storage of 71,000 acre-feet would then be available for flood control. Appendix L, Flood Damage Reduction Alternatives, provides additional discussion on considered modifications to Baldhill Dam. Appendix B, Hydrology, and Appendix K, Geotechnical, also provide additional data on the proposed raise of Baldhill Dam. The project would be operated to maintain the pool at elevation 1266 during summer and fall to ensure that water is available for downstream

water supply needs. The pool would be drawn down as necessary during fall and winter to provide storage for floodwater during spring runoff. Drawdowns to the 1257 level would be considered when severe spring floods are predicted. The stored floodwaters would be released as quickly as possible without incurring additional damages downstream to minimize environmental damages in the flood pool area of Lake Ashtabula and to have the flood storage available for another flood as soon as possible.

Under the Dam Safety Assurance Program, major upgrading of the Baldhill Dam is required. The upgrading would result in major changes to the existing embankment and main public use area because construction of additional spillway capacity on the east abutment is needed. The 5-foot raise of Baldhill Dam and changes in the operation for flood control would require the purchase of about 2,700 acres of lands around and upstream of the lake including the acquisition of many cabins and some farmsteads and some additional modifications to the embankment and gated spillway. Many of the cabins that would be purchased could be relocated by the property owners to other sites around the lake. The additional flooding of project lands by the raise would require actions to mitigate for fish and wildlife losses. The mitigation measures are described in Appendix D, Environmental Resources; Appendix L, Flood Damage Reduction Alternatives; and Appendix N, Fish and Wildlife Coordination Act Report. Several aspects of the plan that would enhance the natural resources around Lake Ashtabula include control of the cattle grazing on Federal property around the lake, development of subimpoundments at the upper end of the lake, and use of aerators in the lake.

Levees and Diversion Channel at West Fargo/Riverside

The levees and diversion channel at West Fargo/Riverside consist of two segments of levees, a flood diversion channel and associated control structures, interior drainage facilities, and other features which provide a very high degree of flood protection (standard project flood) for the cities of West Fargo and Riverside. Additional information on the project is also presented in Appendix C, Hydraulic Analysis and Interior Drainage Design; Appendix L, Flood Damage Reduction Alternatives; and Appendix K, Geotechnical Design Considerations.

The operation of the project calls for closure of the control structures at the upstream and downstream river crossing whenever river flows or stages at West Fargo reach damaging levels. Sheyenne River flows would then be diverted through the diversion channel. During low and normal flows, the Sheyenne River would flow through the natural river channel. The flood diversion channel would be sized to pass flows comparable to what the Sheyenne River would be capable of handling with some form of effective levees placed along the existing river through West Fargo. The height of the principal levees is planned to be 3 feet above the standard project flood level through the area. Drainage ditches and ponding areas are included to handle interior runoff; the Sheyenne River channel and the Drain 21 channel within the leveed area would serve as ponding areas. The principal levee on the west side of the diversion channel would be a closed loop completely encircling the development. The development within the closed loop levee is primarily commercial and public facilities. There are approximately seven businesses, a historical village complex, the county fairgrounds, a motel, and several other facilities. Access to the area during a standard project flood would be provided to the east by the Main Avenue and 13th Avenue bridges. If the ring levee would be overtopped by the standard project flood, flood depths within the leveed area could average 4 to 6 feet. On the east side of the diversion channel, however, the levee would tie back into high ground near Interstate Highway 94 on the southeast corner and the railroad embankment on the northeast corner. Because of the potential stability problems associated with the soils, the levees would be set back away from major excavations such as the diversion channel.

Shelterbelts would be placed along selected portions of the diversion channel to reduce erosion, reduce the amount of snow accumulating in the channel, and provide wildlife habitat diversity in a generally treeless area. The levees and diversion channel slopes and the set-back areas between the channel and levees would be planted with grasses that would provide the optimum mixture for project operation, wildlife values, and compatibility with nearby developments. Features for enhancement of fish and wildlife values such as increased plantings of shelterbelts for primarily wildlife values would be considered for development at appropriate locations with concurrence and sponsorship of local interests.

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Flood Diversion Channel from Horace to West Fargo

The flood diversion channel from Horace to West Fargo would consist of an excavated grass-lined channel parallel to and about 1 mile west of the Sheyenne River between Horace and West Fargo. The inlet to the channel would be located about 1 mile upstream of Horace. The downstream end of the channel would join the diversion channel around West Fargo/Riverside on the north side of Interstate Highway 94. The diversion channel would be operated to allow low and normal flows to go down the natural Sheyenne River channel. During higher flows, the water arriving at the diversion structure would be divided with flows in the diversion channel gradually increasing as the total flow increased so that when peak flows occur, such as occurred during the 1979 flood, the flows would be about split evenly. The side slope of the channel would be grassed.

PLAN COMPONENTS FOR IMPLEMENTATION BY OTHERS - ESSENTIAL

Several plan components essential to the operation and effectiveness of the plan would have to be implemented by non-Federal interests. These components include floodplain regulations, control of private levee construction, and control of drainage.

Floodplain Regulations

The adoption of floodplain regulations where they do not now exist and enforcement of existing and newly adopted floodplain regulations by the non-Federal agencies which regulate land use are essential to preserve the flood-carrying capacity of the floodplain and ensure that any development in a flood prone area does not subject the development to unwarranted flood risks. The floodway should be preserved for the passage of large floods. In the area downstream of about river mile 75 of the Sheyenne River near Kindred, regulation would include not only buildings but all road construction in about a 5-mile wide strip from near Kindred to the mouth of the Sheyenne River. Roads raised

without providing for floodwater-carrying capacity could change the flood characteristics of the area and result in significantly worsened flood damages in some areas. Generally, the 1-percent chance flood is used as the base flood for regulation purposes; this flood should be used for all portions of the basin except the area downstream from river mile 75 where larger floods, such as the standard project flood, should also be considered. The effectiveness and integrity of the levees and diversion at West Fargo/Riverside depends on the preservation of the flood-carrying capacities of the upstream and surrounding areas for floods up to at least the standard project flood. Roads and railroads in the area should not be raised without providing for sufficient flood-passing capacity. Floodplain regulations would prevent increases in flood damages resulting from new construction outside protected areas.

Control of Private Levee Construction

Public regulation of private levee construction is necessary to ensure that flood levels are not increased upstream or downstream of the private levees. Any increase in flood levels caused by private levee construction could jeopardize the protection provided by other plan components and could worsen flood damages in some areas. Individual ring levees around a farmstead or residence which do not affect floodplain storage or flood-carrying capacities are not of concern. However, any continuous stretch of levee which parallels the river, preventing the breakout of floodwaters, and appreciably affects floodplain storage or flood-carrying capacities is of concern and should be regulated in the public interest. Levee locations and heights should be approved by the water resource districts and the State of North Dakota before levee construction could commence. The existing laws of the State of North Dakota appear to have sufficient authority to provide adequate regulation; however, criteria and rules to be used in the levee regulation need to be developed.

Control of Drainage

Public regulation of drainage is necessary to prevent increases in the frequency or severity of floods. Uncontrolled drainage can change the runoff characteristics of a watershed by reducing the time and increasing the amount of runoff. In some cases, the frequency and magnitude of floods, particularly in the moderate-sized floods, can be increased. Increases in the frequency and/or magnitude of floods resulting from uncontrolled drainage could reduce the effectiveness of the other plan components. If drainage is to occur, proper control structures should be built to ensure that the flood characteristics downstream would not be adversely affected. North Dakota laws now require permits for any drainage projects which have a watershed larger than 80 acres. This law seems to provide sufficient authority; however, the development of criteria and rules to provide effective regulation appear necessary. Control of the drainage should be considered on a basinwide watershed approach. A regulation board or panel would be helpful in providing an effective coordinated operation of future drainage projects. Drainage of any areas of the basin which are now considered "noncontributing" or contribute runoff only during very infrequent events are of particular concern.

PLAN COMPONENTS FOR IMPLEMENTATION BY OTHERS - IMPORTANT TO ACHIEVING OBJECTIVES

The remaining plan components are to be implemented by either other Federal agencies, non-Federal interests, or in some cases in part by the Corps of Engineers and are important to achieve the overall objectives of the plan. These components include flood warning and forecasting, flood emergency measures, flood insurance, multiple-purpose dam on Dead Colt Creek, ring levees at farmsteads and residences, increasing the floodwater storage capacity of existing and drained wetlands, debris removal, flood proofing, encouragement of public control/ownership of riverine lands, and encouragement of more land treatment.

Flood Emergency Measures

For damageable floodplain developments where other plan components do not reduce flood damages, flood emergency measures would prevent damages just before the actual floods. These measures would include temporary emergency levees where they would be cost effective, particularly at Valley City and

Lisbon for those infrequent floods that would exceed the capabilities of the raised Baldhill Dam in keeping flows below damageable levels. Evacuation of people and property from areas under threat of imminent flooding is a prudent measure and one for which contingency plans should always be prepared. Federal, State, and local funds should be used as appropriate, including the use of Corps of Engineers funding for construction of temporary levees when necessary.

Flood Warning and Forecasting

The flood warning and forecasting services of the National Weather Service are necessary for the proper planning and preparation for an anticipated flood from several days up to several months in advance depending on the type of flood. This advance warning is needed for efficient operation of flood control reservoirs and the timely construction or upgrading of temporary levees. Advance warning is also needed for the operation of flood diversion channels. However, flood warning and forecasting has much greater significance under the existing and "future without" project conditions than with the proposed projects in place. Continuation of flood warning and forecasting services would still be needed in the basin.

Flood Insurance

Federally-subsidized flood insurance would be important for existing developments not protected by the proposed plan. However, flood insurance for new developments should be assessed at actuarial rates.

Multiple-Purpose Dam on Dead Colt Creek

A dam and reservoir on Dead Colt Creek near the confluence of Dead Colt Creek with the Sheyenne River would serve several purposes, most noticeably flood control and recreation. The dam with a permanent lake plus additional floodwater storage would provide needed water-based recreational opportunities for residents of Lisbon and the surrounding area. The flood control storage would assist in reducing peak flood discharges for the first peak in the downstream area. When considered with the other plan components, this dam would

provide its most significant flood damage reduction effects to agricultural areas from Kindred to the mouth. The operation of the reservoir would have to consider the effects of releases on downstream areas and would have to be coordinated with releases from Baldhill Dam to ensure that peak flood discharges during the second peak on the Sheyenne River are considered in reservoir operation. This plan component is being developed by non-Federal agencies in North Dakota.

Ring Levees at Farmsteads and Residences

Ring levees at farmsteads and residences in rural floodplain areas, particularly in the reach from Kindred to Horace and from West Fargo to the mouth of the Sheyenne River, would provide protection from floods to the residents of existing dwellings outside of the protection provided by the other plan components. The concept of ring levees as discussed here would also include other flood proofing or nonstructural flood damage reduction techniques that may be more appropriate or economical for specific structures. These levees would be designed to provide protection from the base flood as defined for that reach of the river. Criteria for the design of these levees would be anticipated to be comparable to the design criteria established by the Soil Conservation Service for this type of situation. Care would have to be taken in the development of these ring levees that flood stages would not be increased by the raising of a driveway, road, levee, or other continuous feature that would restrict the flood-carrying capacity of the river. This measure is intended for existing development only, with new developments being controlled by floodplain regulations.

The U.S. Soil Conservation Service has an ongoing program for these type of ring levees which appears to be applicable to these portions of the basin. Non-Federal interests would be instrumental in implementing this component. Further evaluation of potential participation by the Corps of Engineers could also be undertaken through the feasibility study of farmstead ring levees in

The Red River of the North basin or through the urban study for the Fargo-Moorhead metropolitan area. At specific groups of residences, such as Harwood, Rivertree, and Brooktree, further evaluation for Federal participation through the Corps of Engineers could be considerd as part of the small projects program, under the ring levee program, or under the urban study program.

Increasing the Floodwater Storage Capacity of Existing or Drained Wetlands

When considered as a part of the overall plan, the use of existing or drained wetlands for the storage of floodwaters could reduce flood discharges for the first peak on the Sheyenne River if accomplished in sufficient numbers in the reach from Kindred to Valley City. The major flood control benefits would be to agricultural interests from Kindred to Horace and north of West Fargo. While it is unlikely that a large number of drained wetlands would be restored or existing wetlands would be modified just to provide floodwater storage, it is probable that the wetland areas would be developed for their wildlife and environmental values. When the restoration of drained wetlands or the management or preservation of existing wetlands is being accomplished for wildlife values, compatible plans to use portions of the wetland for wetland storage could be developed. The U.S. Bureau of Reclamation is considering drained wetland areas for restoration and use as mitigation for the Garrison Diversion Unit. Any of these mitigation areas being considered in the Sheyenne River basin should include the consideration of multiple-use, with operation of the wetland areas for floodwater storage as well as fish and wildlife values.

Other agencies, such as the Fish and Wildlife Service, should consider the multiple-use concept and inclusion of floodwater storage as a purpose of their wetland acquisition and/or management. Through the multiple-use of wetlands, storage of floodwaters could become a reality.

The placing of control structures on existing drains could also be considered under this concept, with the entity responsible for regulation of the drain initiating the steps needed to place such controls on the drain.

Debris Removal

Debris removal from bridges and other channel constrictions along the Sheyenne River before, during, and after floods will help alleviate localized flooding problems in the vicinity of the blocked constriction and could also make a difference in affecting downstream flooding by determining how, when, and where breakout flows occur. The debris removal would be accomplished by non-Federal interests, probably the Water Resource Districts.

Flood Proofing

Flood proofing should be considered in cases of existing flood prone developments where the flood proofing would be economically feasible, practical, and supported by non-Federal interests. Its use would be considered in some cases in lieu of ring levees at farmsteads and residences.

Encouragement of Public Control/Ownership of Riverine Lands

Use of public acquisition, easements, or land use controls over riverine lands could preserve many of the natural environment and floodplain values associated with the wooded strips along the rivers. For most of the Sheyenne River this type of control would be appropriate at the State or local level of government.

Encouragement of More Land Treatment

Use of more land treatment measures throughout the basin could provide water quality and erosion control benefits. Encouragement of landowners by non-Federal and Federal interests could help improve the aesthetic and environmental setting of the basin.

ASSESSMENT AND EVALUATION OF THE SELECTED PLAN

The selected plan represents a comprehensive approach to reducing flood damages throughout the basin while recognizing the environmental, social well-being, economic, and implementability constraints and considerations.

An assessment and evaluation of the entire plan considering all plan components would be beneficial. However, uncertainty as to degree of implementation with several of the components scheduled for non-Federal or other Federal agency responsibility requires that the primary assessment and evaluation consider only the following components:

- Raise of Baldhill Dam.
- Levees and diversion at West Fargo/Riverside.
- Flood diversion channel - Horace to West Fargo.
- Control of drainage.
- Floodplain regulations.
- Control of private levee construction.

Flood Damage Reduction

The effectiveness of the plan in reducing flood damages at various locations throughout the Sheyenne River basin is presented in table M-24. Flood damages in the basin would be reduced by about 78 percent. The greatest reductions occur at West Fargo/Riverside where protection is provided for the standard project flood and damages are reduced by 99 percent. Although reductions in flood damages for the 1-percent chance flood in areas outside of West Fargo/Riverside are not quantified for most areas, enforcement of floodplain regulation in these areas would reduce the growth of future flood damageable development. At Valley City, the raise of Baldhill Dam for flood control would reduce damages for the 1-percent chance flood about 18 percent. However, greater reductions may be possible depending on the final operating plan developed in future, more detailed studies. Damages would be reduced in the agricultural and residential areas from Kindred to West Fargo in greater amounts than are shown in table M-24. Preliminary estimates indicate that substantial additional benefits would accrue to the raise of Baldhill Dam in these reaches. Implementation of the other components such as Dead Colt Creek Dam and ring levees at farmsteads and residences could further reduce damages to existing developments. The damages from the more frequent floods would be significantly reduced, and damages from the standard project flood would be less with the plan than without the plan.

Table M-24 - Effectiveness of selected plan in reducing flood damages(1)(2)

Damage location	Average annual conditions: Damages without plan	Average annual conditions: Benefits with plan	Average annual conditions: Percent damages reduced	5-percent chance flood: Damages with-out plan	5-percent chance flood: Benefits with plan	5-percent chance flood: Percent damages reduced	1-percent chance flood: Damages with-out plan	1-percent chance flood: Benefits with plan	1-percent chance flood: Percent damages reduced	Standard project flood: Damages without plan	Standard project flood: Benefits with plan	Standard project flood: Percent damages reduced	Magnitude of flood for which emergency measures would be needed to supplement plan (3)
Urban													
Valley City	$1,943,600	$1,290,000	66.4	$6,700,000	$5,600,000	83	$25,900,000	$4,800,000	18.5	$29,000,000	0	0	3.0
Lisbon	376,700	110,000	29.2	1,627,000	167,000	10	4,172,000	some	--	6,884,000	0	0	11.5
Horace	492,600	439,000	89.1	1 640,000	1,640,000	100	1,888,000	some	--	1,940,000	0	0	2.0
West Fargo/Riverside	19,811,800	19,551,000	98.7	59,973,000	59,973,000	100	65,709,000	65,709,000	100	68,838,000	$68,838,000	100	SPF
Harwood	475,800	--	--	1,851,000	0	0	2,712,000	0	0	3,650,000	0	0	31
Other	591,100	--	--	2,936,000	0	0	4,500,000	0	0	5,172,000	0	0	31
Subtotal	23,691,600	21,390,000	90.3	74,727,000	67,380,000	--	81,581,000	70,509,000	--	115,484,000	68,838,000	--	--
Rural residential(4)													
Kindred-Horace	1,054,500	--	--	4,589,000	--	--	5,215,000	--	--	5,789,000	--	--	26
Horace-West Fargo	1,032,200	911,000	88.3	3,911,000	3,911,000	100	4,302,000	some	--	4,407,000	0	0	2
West Fargo-south	1,821,400	--	--	7,451,000	--	--	9,554,000	--	--	10,900,000	--	--	25
Other	--	--	--	--	--	--	--	--	--	--	--	--	--
Subtotal	3,908,100	911,000	23.3	15,951,000	3,911,000	--	19,071,000	--	--	21,096,000	--	--	--
Agricultural													
Kindred-West Fargo	181,600	30,000	16.5	522,000	182,000	35	1,533,000	0	0	2,273,000	0	0	48
West Fargo-south	873,400	41,000	4.7	3,642,000	139,000	4.6	4,833,000	166,000	3.4	5,010,000	179,000	3.6	61
Other	88,400	11,600	13.1	330,000	37,000	11.5	515,000	0	0	772,000	0	0	52
Subtotal	1,143,400	82,600	7.2	4,494,000	358,000	--	6,881,000	166,000	--	8,055,000	179,000	--	--
Transportation	196,100	48,000	24.5	975 000	416,000	42	1,247,000	242,000	19.4	1,538,000	9,000	0.6	--
Total	28,939,200	22,431,600	77.5	96,147,000	72,065,000	74.9	108,780,000	70,917,000	65.2	146,173,000	69,173,000	47.2	--

(1) October 1981 prices, 7 5/8 percent interest. Indexes are the same as those shown in table G-25.
(2) Based only on flood damage reductions provided by the raise of Baldhill Dam, levees and diversions at West Fargo/Riverside, and flood diversion from Horace to West Fargo. Benefits and effectiveness of other components are not included in this table.
(3) Expressed in percent chance frequency of occurrence.
(4) Includes only those areas labeled "nonurban".

Environmental Considerations

The plan would provide net benefits to the environmental quality account. The levees and diversion at West Fargo/Riverside and the flood diversion channel from Horace to West Fargo with the grassed areas and selected areas of shelterbelts would improve the environmental quality of the area. The raise of Baldhill Dam would have some limited adverse effects because of temporary flooding of woodlands and other habitats; however, the fish and wildlife mitigation features of the project as well as several potential enhancement features would provide net environmental benefits. Some of the more significant potential enhancement opportunities at Baldhill Dam are (1) the creation of shallow marsh impoundments at the upper end of Lake Ashtabula with management of water levels in the marshes for fish and wildlife, (2) the control of grazing on project lands, and (3) the opportunity to modify slightly the regulation of lake levels and discharges to reduce the magnitude of drawdowns for flood control during the winter months in years of anticipated light to moderate runoff. The control of drainage, floodplain regulation, and control of private levee construction should result in some slight positive environmental effects from the greater consideration given to environmental values associated with drainage and floodplain development.

Social Well-Being Considerations

The plan would provide net benefits to the social well-being account. The improvements to the quality of life for over 15,000 persons greatly overshadow the adverse effects to those persons relocated or otherwise affected. Virtual elimination of flood threat to residents of West Fargo/Riverside and major reductions in the flood threat to residents of Valley City and other parts of the basin would significantly improve the physical and mental well-being of these people. About 3,300 acres of land would be dedicated to public use, and 100 cabins and residences, 6 farmsteads, and 2 church camps would have to be acquired. Most of the property acquisition is associated with the raise of Baldhill Dam. Although the numbers of persons that would be relocated and acres of land that would be acquired give the appearance of a significant social impact, most of the structures involved are lakeshore cabins. These cabins are used periodically throughout the summer and other suitable

locations would be available around the lake. Much of the land around Lake Ashtabula is marginally useful as cropland because of steep slopes and low productivity. Several landowners at the upper end of the lake would be significantly affected by acquisition of their lands. The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 would be used for all properties acquired, thus ensuring that any adverse impacts would be minimized. Incorporation of the ring levees, wetlands, and Dead Colt Creek Dam components would provide additional social well-being benefits and have some additional impacts. The net effect of these components would be beneficial.

Economic Considerations

The plan as recommended for Federal implementation through the Corps of Engineers is economically justified with a benefit-cost ratio of 7.5. Individually, each of the three major components is also economically justified on a last added basis.

Compliance with Executive Orders

Various executive orders and congressional acts have been used in the planning and decision-making process and in the final development of the alternatives, including the selected plan. The assessments made to determine the compliance of the selected plan with Executive Order 11990, Protection of Wetlands; Executive Order 11988, Floodplain Management; Executive Memorandum, Prime and Unique Farmlands; and the Endangered Species Act of 1973, as amended are discussed in the following paragraphs and also in the Environmental Impact Statement.

Executive Order 11990, Protection of Wetlands, 24 May 1977 - The Sheyenne River basin contains many important wetlands. In fact, most of the basin, especially the upper protion, is located in the "Prairie Pothole Region" and is considered significant waterfowl production habitat for the North American continent. Because of this fact, wetlands protection and enhancement is a planning objective and various alternatives have been formulated to protect these values.

Various features of the selected plan would affect wetlands. The most noticeable adverse effects would result from the 5-foot raise of the flood pool at Lake Ashtabula. However, these impacts are not considered significant because the wetlands are located at the upper end of the existing permanent pool and are expected to remain in the same general location without a drastic change in total acreage.

Various measures have been included in the selected plan to protect and enhance the wetlands of the basin. These measures include creating subimpoundments at Lake Ashtabula, restoring wetlands and on-land storage of water, and the control of future wetland drainage.

The selected plan is considered to be the most responsive to the planning objectives and would not result in unacceptable impacts on the environment or wetlands.

Executive Order 11988, Floodplain Management, 24 May 1977 - This executive order requires Federal agencies to recognize the significant values of floodplains and consider the public benefits that would be realized from restoring and preserving floodplains. The principal purpose of this study was to evaluate various methods of reducing flood damages, and, since the conclusions and recommendations of this study do affect and propose changes in floodplain uses, the significant values of the floodplain must be recognized. The selected plan does propose actions which are located in and do affect the uses of the floodplain. The actions proposed for non-Federal or other Federal agency implementation are as important in their effects as the three actions proposed for implementation by the Corps of Engineers. Table M-25 presents the summary assessment of the proposed plan components considering Executive Order 11988. The components would provide both potential beneficial and adverse effects on the natural and beneficial values of the floodplain. Wherever possible, actions have been taken to preserve or improve floodplain values and minimize any potential adverse effects. The residual adverse effects would be relatively minor. The net effect of the plan would be beneficial because the plan would reduce flood damages in the basin, recognizing the flood hazards of the basin, and would provide information on ways to preserve the natural and beneficial values of the floodplain. The proposed plan of action represents the most

Table M-25 - Summary assessment of components considering Executive Order 11988

Item	Corps of Engineers implementation: Raise of Baldhill Dam	Levees and diversion at West Fargo	Diversion channel Horace to West Fargo	Non-Federal or other Federal implementation: Control drainage	Control private levee construction	Floodplain regulations	Ring levees at residences and farmsteads	Dam on Dead Colt Creek	Increase flood-water storage on wetlands	Overall plan
1. Is project or action located in floodplain?	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes
2. Reason for location in floodplain	To reduce flood damages in Valley City, Lisbon, and other areas downstream	To reduce flood damages in West Fargo and Riverside	To reduce flood damages in Horace and area between Horace and West Fargo	--	To prevent future increases in flood damages in reach from Kindred to Red River of the North.	To prevent future increases in flood damages.	To reduce flood damages at residences and farmsteads in rural areas.	To reduce flood damages at downstream locations and provide water-based recreation.	--	To reduce flood damages in basin
3. Does this action conform to State or local floodplain protection standards?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4. Does this action affect the natural and beneficial values of the floodplain?	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes
-Directly (1)	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes
-Indirectly (2)	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes
-Beneficially	No	Yes	No	No	Yes	Yes	No	No	No	Yes
-Adversely	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes
-Significant adverse magnitude	No	No	No	No	No	No	No	No	No	No
5. Were steps taken to minimize potential harm to or within the floodplain?	Yes, but limited	Yes	Yes	--	--	--	No specific steps	--	--	Yes
6. Were other viable alternatives to this action considered?	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes

(1) Effects which are caused by the construction, operation, or implementation of the action at the site of implementation.
(2) Effects which are caused downstream or away from the actual site of implementation, such as the area protected by a levee or the area downstream of a dam.

AD-A146 716 GENERAL REEVALUATION AND ENVIRONMENTAL IMPACT STATEMENT FOR FLOOD CONTROL..(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT JAN 84

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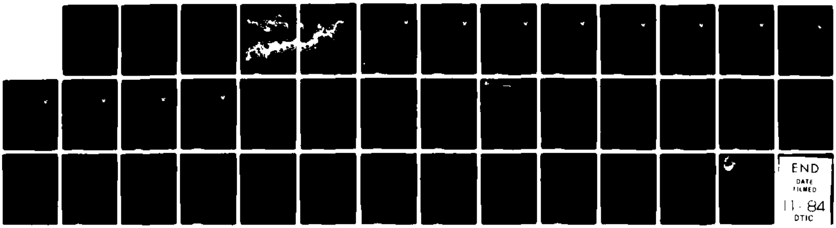
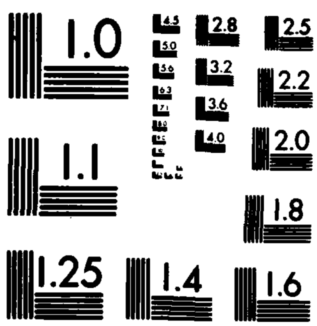




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

practical alternative plan for management of the Sheyenne River floodplain and would comply with Executive Order 11988.

Executive Memorandum, Analysis of Impacts on Prime and Unique Farmlands in EIS, CEQ Memorandum, 30 August 1976 - Much of the basin, including the floodplain, upland areas, and the Red River Valley downstream of Kindred, is classified as prime farmland. (See plates D-6 through D-9 in Appendix D for their location.) The diversion structures would be constructed in areas designated as prime farmland. Secondary impacts would result from increased development because of reduced flooding. The commitment of prime farmland to the construction of flood damage reduction structures is considered an acceptable tradeoff and use of the resource.

Public Law 96-156, Endangered Species Act of 1973, as Amended - In accordance with the Endangered Species Act, as amended, coordination with the Fish and Wildlife Service was conducted to determine the presence of any species included on the Federal list of endangered or threatened species in the study area and any impacts the proposed plan could have on endangered or threatened species. The peregrine falcon and the bald eagle were the species found on the lists. The selected plan components should have no adverse effects on the continued existence or critical habitat of either species.

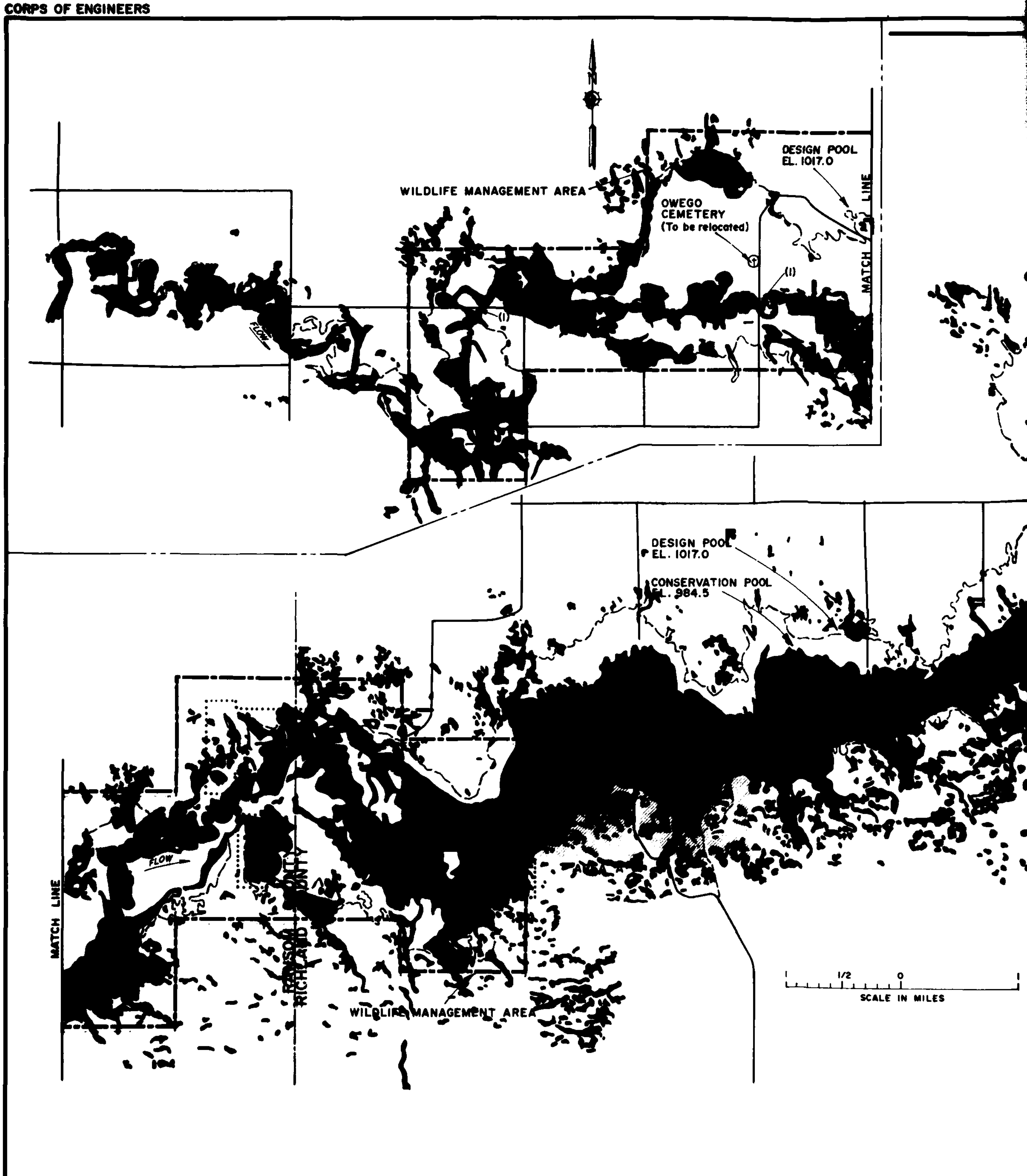
Coordination and Comments Received on the Selected Plan

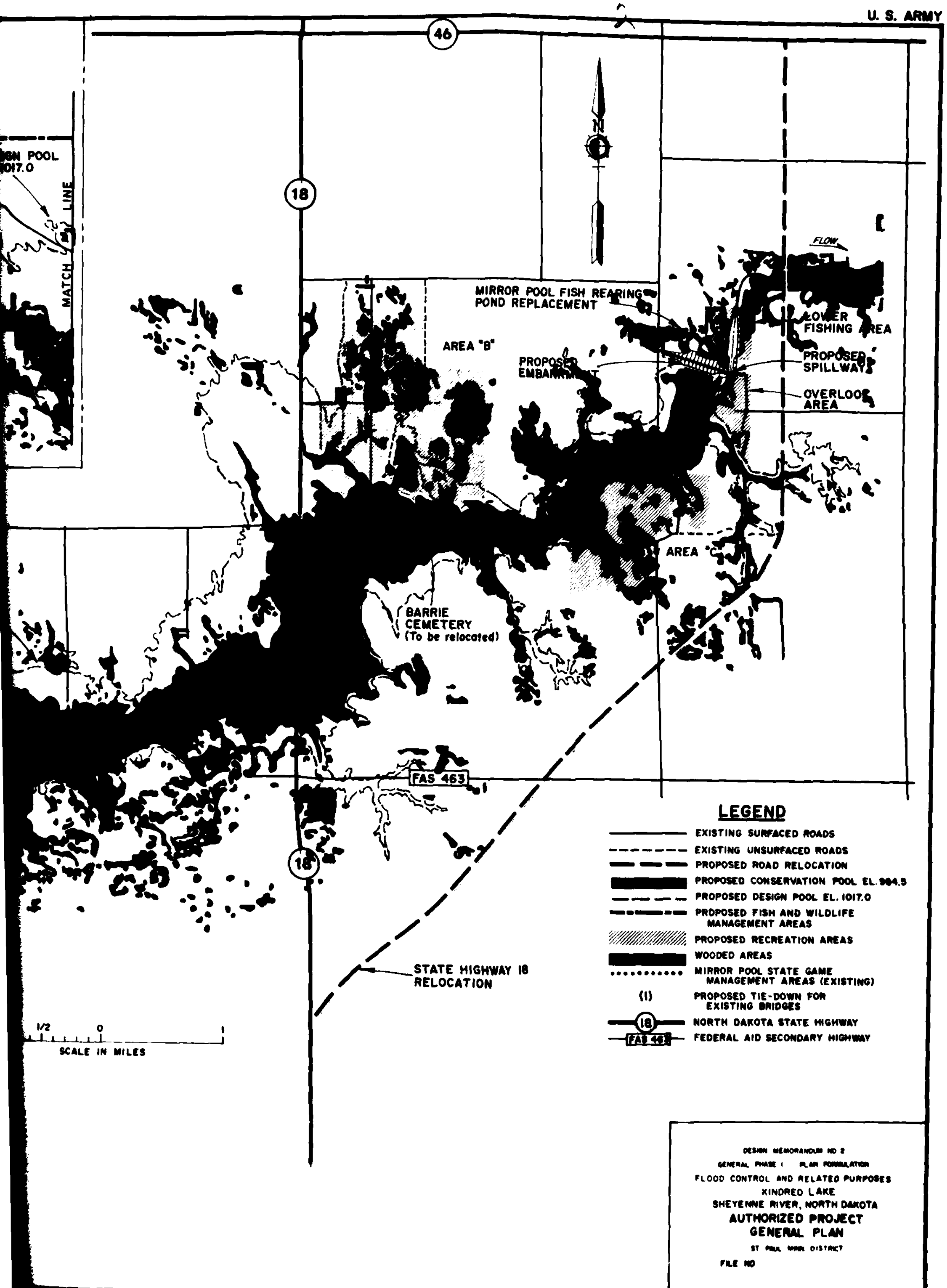
The results of the study were coordinated with Federal and State agencies; local and regional government entities; and organizations, groups, and interested individuals. Letters of comment received are printed and discussed in the Environmental Impact Statement, Appendix A, and the main portion of the General Reevluation Report. The selected plan and its components generally received favorable comments from agencies and regional interests.

The most significant adverse comments from property owners and other interests regarding the raise of Baldhill Dam. A large number of those views were expressed by members of the Evangelical Free Church concerning purchase of the Cooperstown Bible Camp as a portion of the property acquisition needed for the 5-foot raise of Baldhill Dam.

The report was revised to reflect the comments received. The raise of Baldhill Dam was retained as a plan component because the decision-making process that led to inclusion of the raise recognized the adverse impacts and because the benefits of the raise are estimated to more than offset the adverse impacts.

Additional information on cost sharing, implementation responsibilities, and responses to comments on the plan is in the main portion of this General Reevaluation Report.


WILDLIFE MANAGEMENT AREA
DESIGN POOL
EL. 1017.0
OWEGO
CEMETERY
(To be relocated)
(1)
(1)
MATCH LINE
FLOW
DESIGN POOL
EL. 1017.0
CONSERVATION POOL
EL. 984.5
MATCH LINE
FLOW
RANSOM COUNTY
RICHLAND COUNTY
WILDLIFE MANAGEMENT AREA
1/2
0
1
SCALE IN MILES



U. S. ARMY
46
18
N
MATCH LINE
DESIGN POOL
1017.0
FLOW
MIRROR POOL FISH REARING
POND REPLACEMENT
LOWER
FISHING AREA
AREA "B"
PROPOSED
EMBANKMENT
PROPOSED
SPILLWAY
OVERLOOK
AREA
AREA "C"
BARRIE
CEMETERY
(To be relocated)
FAS 463
STATE HIGHWAY 18
RELOCATION
1/2
0
1
SCALE IN MILES
LEGEND
EXISTING SURFACED ROADS
EXISTING UNSURFACED ROADS
PROPOSED ROAD RELOCATION
PROPOSED CONSERVATION POOL EL. 984.5
PROPOSED DESIGN POOL EL. 1017.0
PROPOSED FISH AND WILDLIFE
MANAGEMENT AREAS
PROPOSED RECREATION AREAS
WOODED AREAS
MIRROR POOL STATE GAME
MANAGEMENT AREAS (EXISTING)
(1)
PROPOSED TIE-DOWN FOR
EXISTING BRIDGES
NORTH DAKOTA STATE HIGHWAY
FEDERAL AID SECONDARY HIGHWAY
DESIGN MEMORANDUM NO 2
GENERAL PHASE I PLAN FORMULATION
FLOOD CONTROL AND RELATED PURPOSES
KINDRED LAKE
SHEYENNE RIVER, NORTH DAKOTA
AUTHORIZED PROJECT
GENERAL PLAN
ST PAUL MINN DISTRICT
FILE NO

PLATE M 1

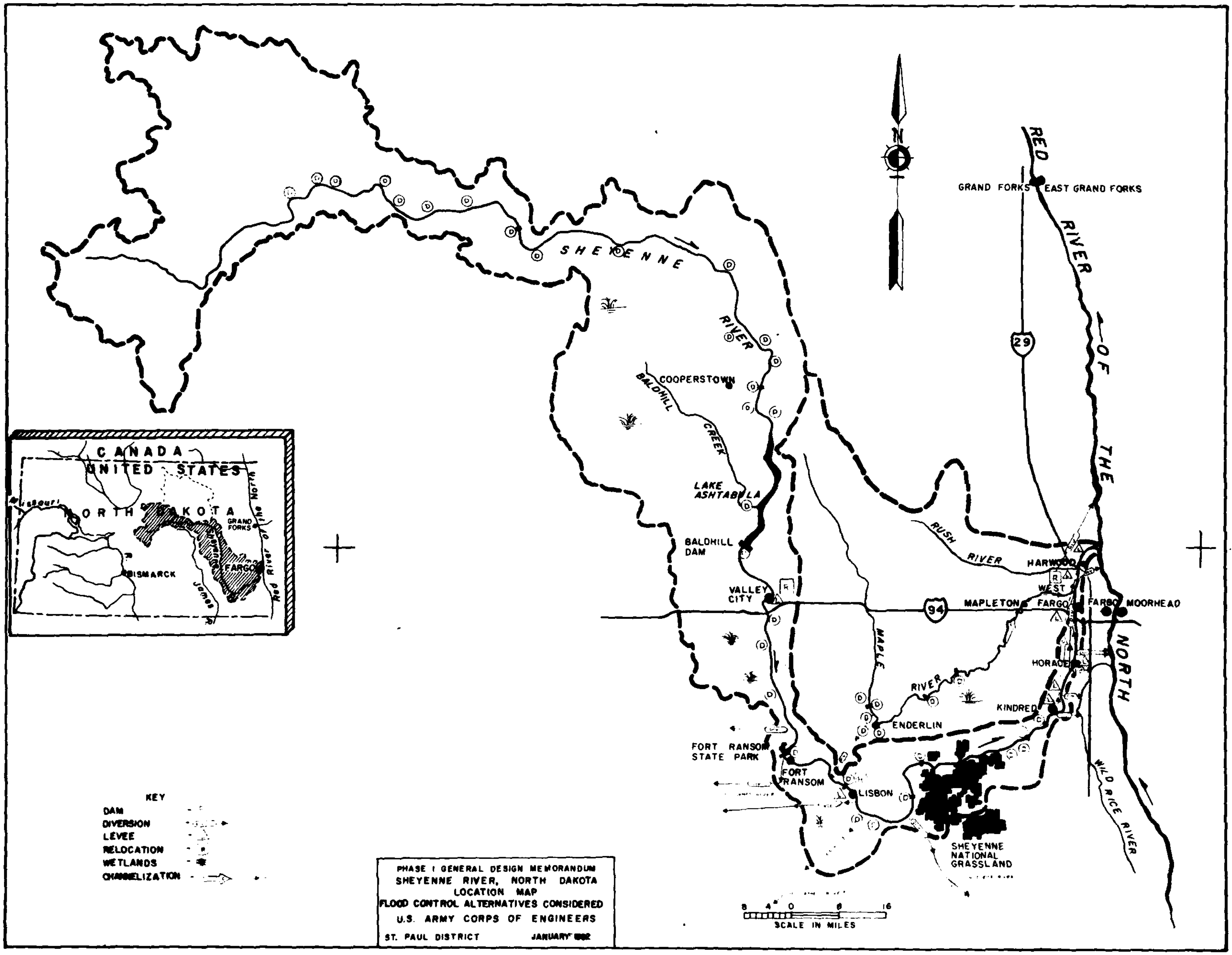
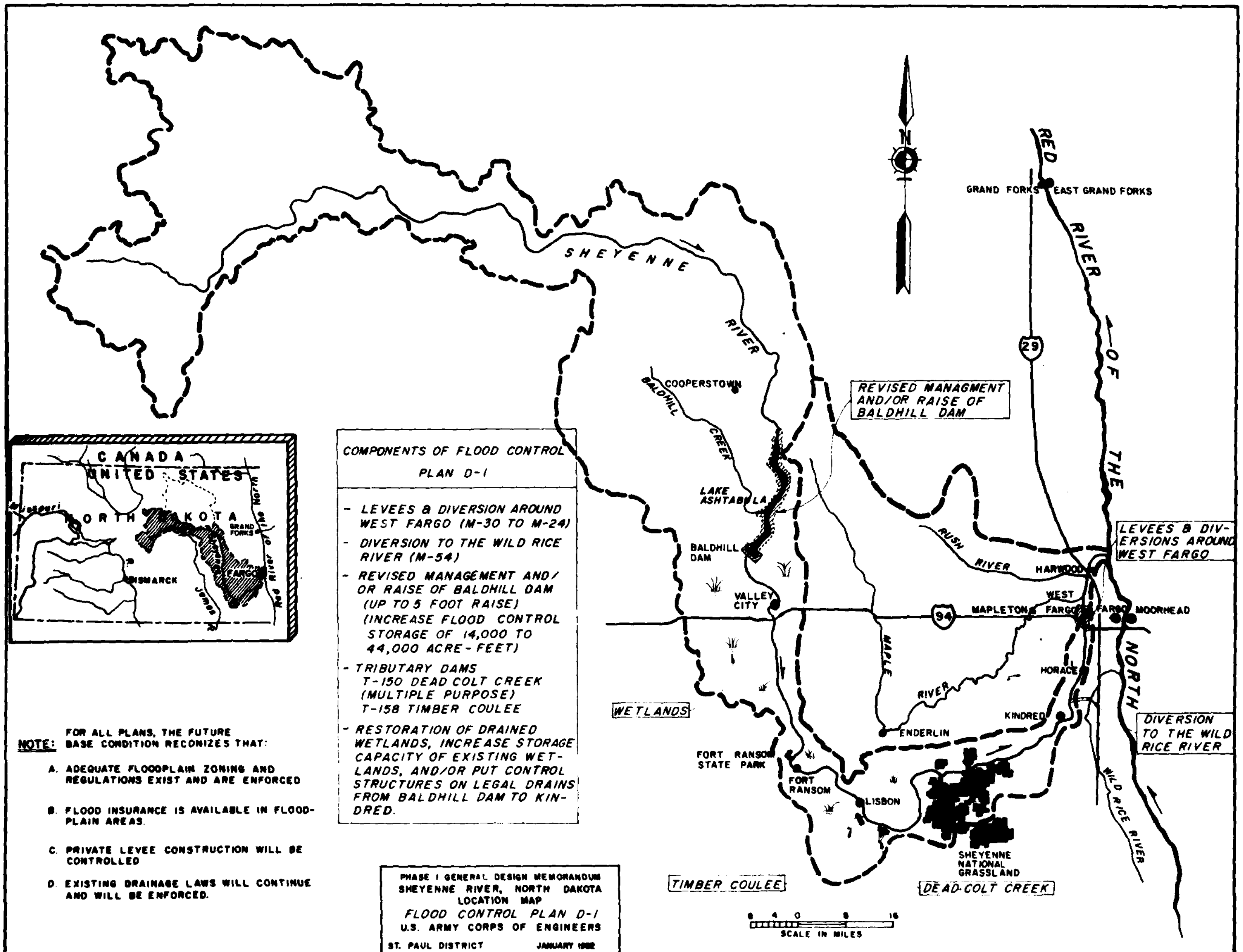

RED RIVER OF THE NORTH
GRAND FORKS
EAST GRAND FORKS
29
SHEYENNE RIVER
COOPERSTOWN
BALDHILL CREEK
LAKE ASHTABULA
BALDHILL DAM
VALLEY CITY
94
MAPLETON
WEST FARGO
FARGO
MOORHEAD
HARWOOD
RUSH RIVER
MAPLE RIVER
HORACE
KINDRED
ENDERLIN
FORT RANSOM STATE PARK
FORT RANSOM
LISBON
SHEYENNE NATIONAL GRASSLAND
WILD RICE RIVER
CANADA
UNITED STATES
NORTH DAKOTA
GRAND FORKS
BISMARCK
Missouri
James
Red River of the North
KEY
DAM
DIVERSION
LEVEE
RELOCATION
WETLANDS
CHANNELIZATION
PHASE I GENERAL DESIGN MEMORANDUM
SHEYENNE RIVER, NORTH DAKOTA
LOCATION MAP
FLOOD CONTROL ALTERNATIVES CONSIDERED
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
JANUARY
8 4 0 8 16
SCALE IN MILES

PLATE M-2



COMPONENTS OF FLOOD CONTROL

PLAN D-1

- LEVEES & DIVERSION AROUND WEST FARGO (M-30 TO M-24)
- DIVERSION TO THE WILD RICE RIVER (M-54)
- REVISED MANAGEMENT AND/ OR RAISE OF BALDHILL DAM (UP TO 5 FOOT RAISE) (INCREASE FLOOD CONTROL STORAGE OF 14,000 TO 44,000 ACRE-FEET)
- TRIBUTARY DAMS
  T-150 DEAD COLT CREEK (MULTIPLE PURPOSE)
  T-158 TIMBER COULEE
- RESTORATION OF DRAINED WETLANDS, INCREASE STORAGE CAPACITY OF EXISTING WETLANDS, AND/OR PUT CONTROL STRUCTURES ON LEGAL DRAINS FROM BALDHILL DAM TO KINDRED.

NOTE: FOR ALL PLANS, THE FUTURE BASE CONDITION RECONIZES THAT:

A. ADEQUATE FLOODPLAIN ZONING AND REGULATIONS EXIST AND ARE ENFORCED

B. FLOOD INSURANCE IS AVAILABLE IN FLOOD-PLAIN AREAS.

C. PRIVATE LEVEE CONSTRUCTION WILL BE CONTROLLED

D. EXISTING DRAINAGE LAWS WILL CONTINUE AND WILL BE ENFORCED.

PHASE I GENERAL DESIGN MEMORANDUM
SHEYENNE RIVER, NORTH DAKOTA
LOCATION MAP
FLOOD CONTROL PLAN D-1
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT JANUARY 1982

PLATE M-3

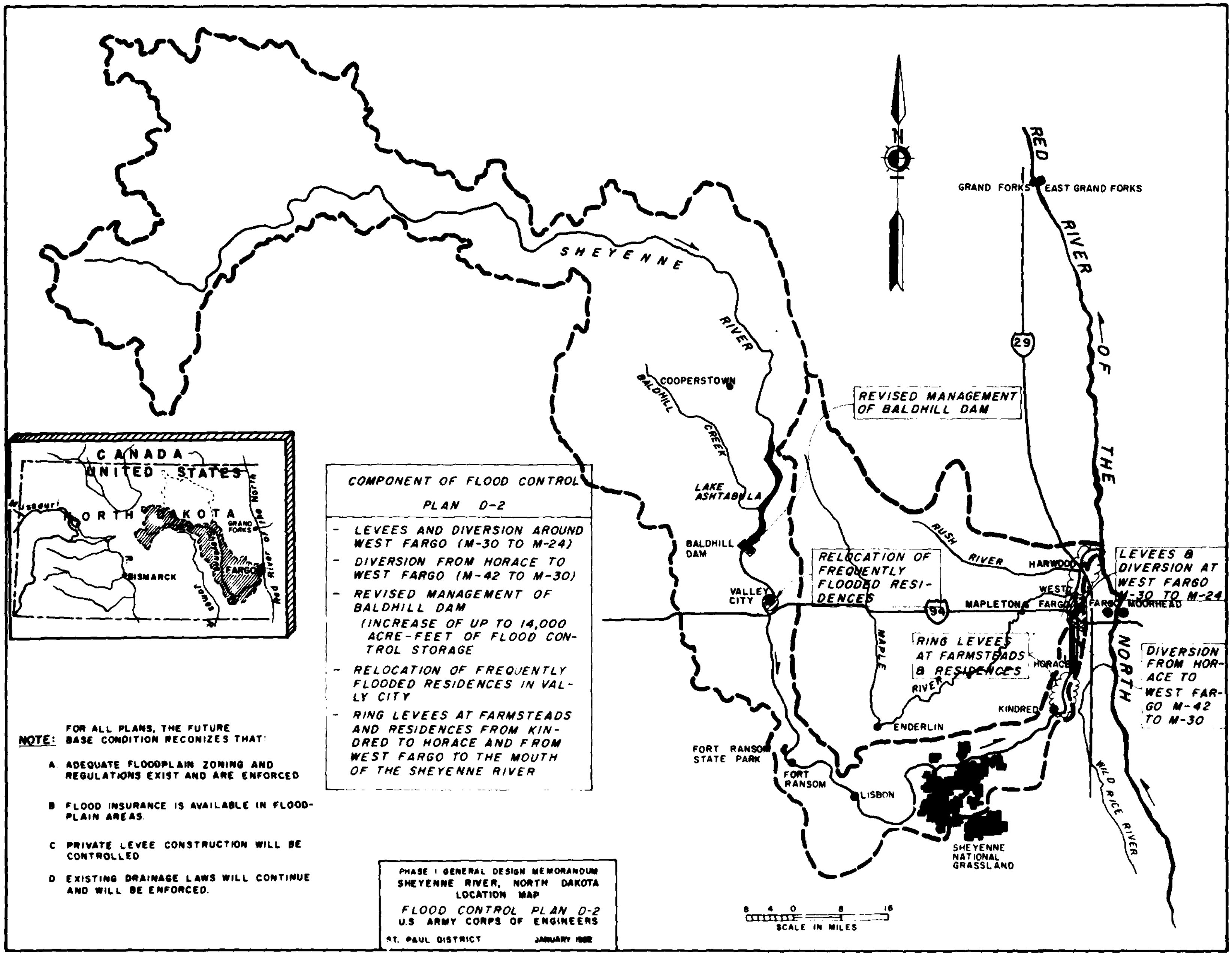
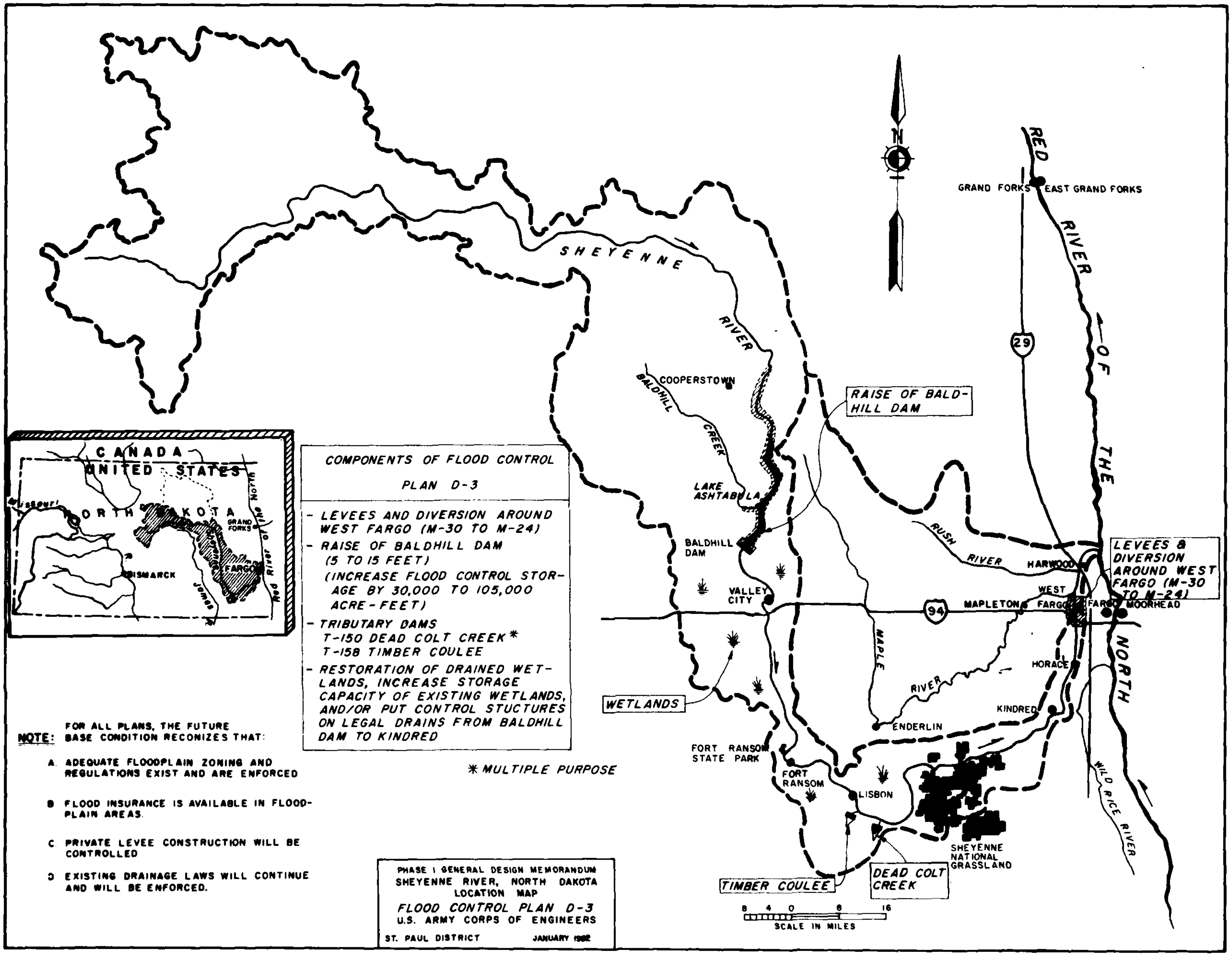

RED RIVER OF THE NORTH
GRAND FORKS
EAST GRAND FORKS
29
SHEYENNE RIVER
COOPERSTOWN
BALDHILL CREEK
LAKE ASHTABULA
BALDHILL DAM
VALLEY CITY
REVISED MANAGEMENT OF BALDHILL DAM
RELOCATION OF FREQUENTLY FLOODED RESIDENCES
RUSH RIVER
HARWOOD
WEST FARGO
FARGO
MOORHEAD
MAPLETON
94
LEVEES & DIVERSION AT WEST FARGO M-30 TO M-24
DIVERSION FROM HORACE TO WEST FARGO M-42 TO M-30
RING LEVEES AT FARMSTEADS & RESIDENCES
HORACE
MAPLE
RIVER
ENDERLIN
KINDRED
FORT RANSOM STATE PARK
FORT RANSOM
LISBON
SHEYENNE NATIONAL GRASSLAND
WILD RICE RIVER
8 4 0 8 16
SCALE IN MILES
CANADA
UNITED STATES
NORTH DAKOTA
Missouri
R.
BISMARCK
James
GRAND FORKS
FARGO
Red River of the North
COMPONENT OF FLOOD CONTROL
PLAN D-2
- LEVEES AND DIVERSION AROUND WEST FARGO (M-30 TO M-24)
- DIVERSION FROM HORACE TO WEST FARGO (M-42 TO M-30)
- REVISED MANAGEMENT OF BALDHILL DAM (INCREASE OF UP TO 14,000 ACRE-FEET OF FLOOD CONTROL STORAGE
- RELOCATION OF FREQUENTLY FLOODED RESIDENCES IN VALLY CITY
- RING LEVEES AT FARMSTEADS AND RESIDENCES FROM KINDRED TO HORACE AND FROM WEST FARGO TO THE MOUTH OF THE SHEYENNE RIVER
NOTE: FOR ALL PLANS, THE FUTURE BASE CONDITION RECONIZES THAT:
A. ADEQUATE FLOODPLAIN ZONING AND REGULATIONS EXIST AND ARE ENFORCED
B. FLOOD INSURANCE IS AVAILABLE IN FLOODPLAIN AREAS.
C. PRIVATE LEVEE CONSTRUCTION WILL BE CONTROLLED
D. EXISTING DRAINAGE LAWS WILL CONTINUE AND WILL BE ENFORCED.
PHASE I GENERAL DESIGN MEMORANDUM
SHEYENNE RIVER, NORTH DAKOTA
LOCATION MAP
FLOOD CONTROL PLAN D-2
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
JANUARY 1982

PLATE M-4



COMPONENTS OF FLOOD CONTROL

PLAN D-3

- LEVEES AND DIVERSION AROUND WEST FARGO (M-30 TO M-24)
- RAISE OF BALDHILL DAM (5 TO 15 FEET) (INCREASE FLOOD CONTROL STORAGE BY 30,000 TO 105,000 ACRE-FEET)
- TRIBUTARY DAMS
  T-150 DEAD COLT CREEK*
  T-158 TIMBER COULEE
- RESTORATION OF DRAINED WETLANDS, INCREASE STORAGE CAPACITY OF EXISTING WETLANDS, AND/OR PUT CONTROL STUCTURES ON LEGAL DRAINS FROM BALDHILL DAM TO KINDRED

* MULTIPLE PURPOSE

NOTE: FOR ALL PLANS, THE FUTURE BASE CONDITION RECONIZES THAT:

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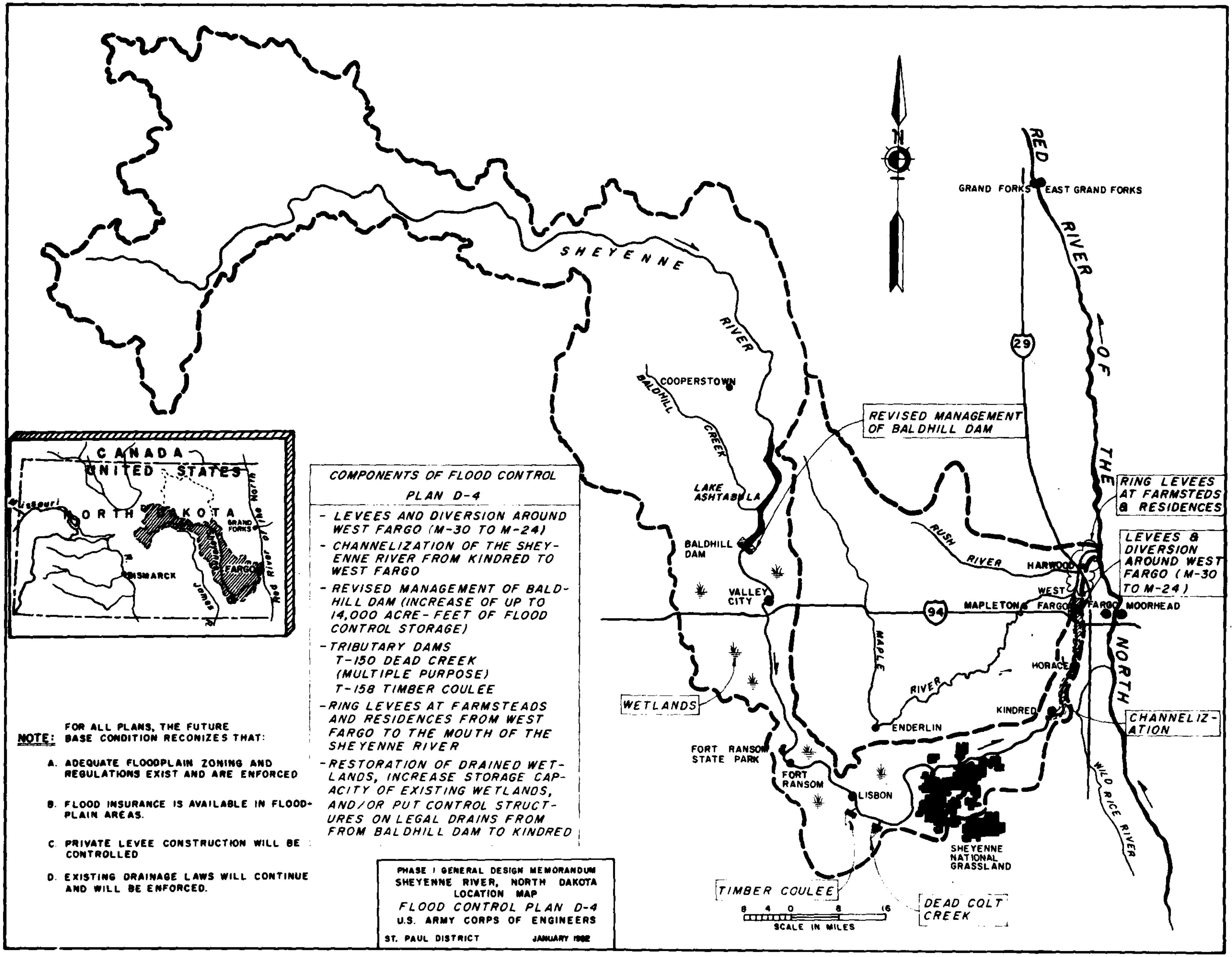
B. FLOOD INSURANCE IS AVAILABLE IN FLOODPLAIN AREAS.

C. PRIVATE LEVEE CONSTRUCTION WILL BE CONTROLLED

D. EXISTING DRAINAGE LAWS WILL CONTINUE AND WILL BE ENFORCED.

PHASE I GENERAL DESIGN MEMORANDUM
SHEYENNE RIVER, NORTH DAKOTA
LOCATION MAP
FLOOD CONTROL PLAN D-3
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT JANUARY 1982



NOTE: FOR ALL PLANS, THE FUTURE BASE CONDITION RECONIZES THAT:

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B. FLOOD INSURANCE IS AVAILABLE IN FLOOD-PLAIN AREAS.

C. PRIVATE LEVEE CONSTRUCTION WILL BE CONTROLLED

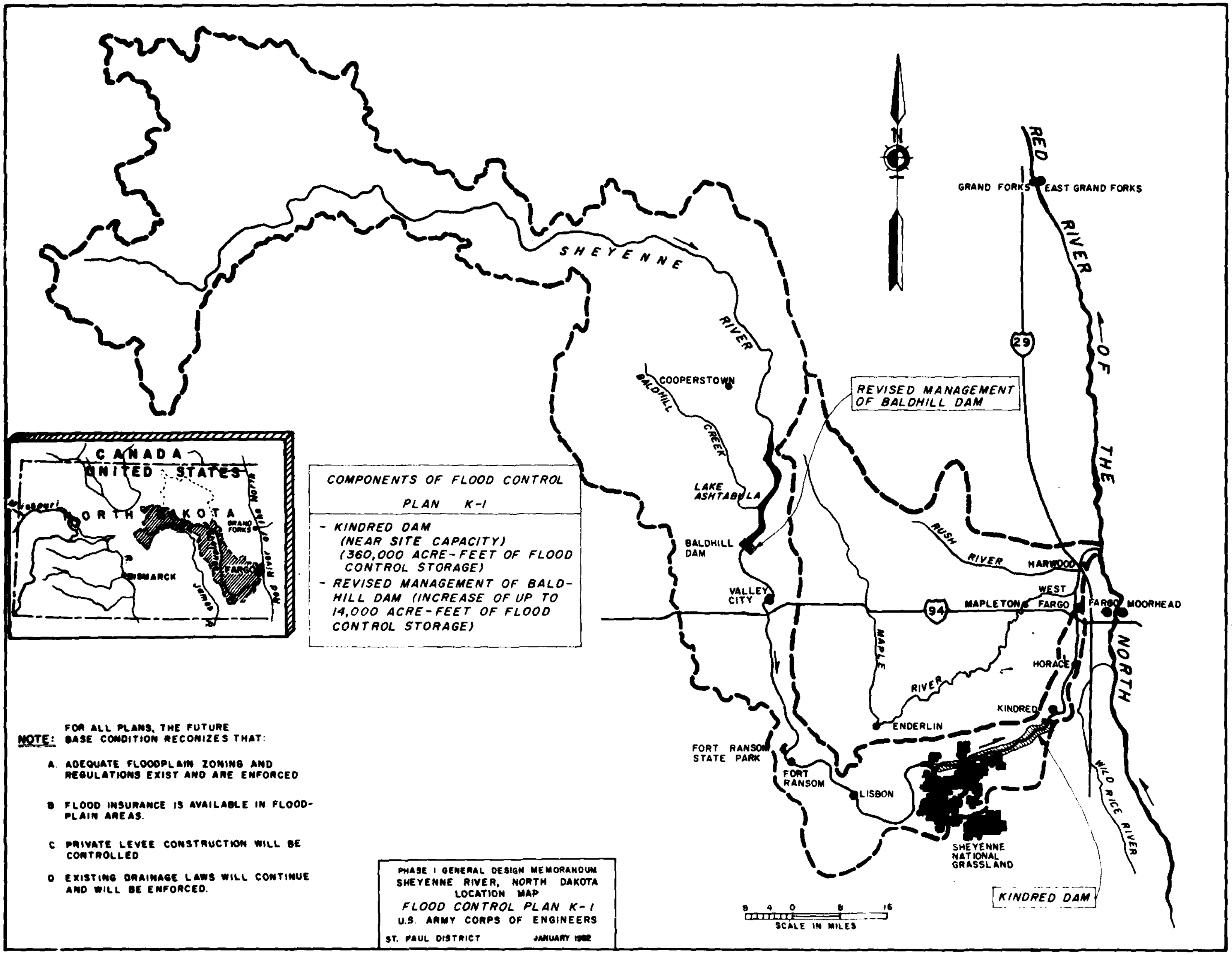
D. EXISTING DRAINAGE LAWS WILL CONTINUE AND WILL BE ENFORCED.

COMPONENTS OF FLOOD CONTROL PLAN D-4

- LEVEES AND DIVERSION AROUND WEST FARGO (M-30 TO M-24)
- CHANNELIZATION OF THE SHEYENNE RIVER FROM KINDRED TO WEST FARGO
- REVISED MANAGEMENT OF BALDHILL DAM (INCREASE OF UP TO 14,000 ACRE-FEET OF FLOOD CONTROL STORAGE)
- TRIBUTARY DAMS
  T-150 DEAD CREEK (MULTIPLE PURPOSE)
  T-158 TIMBER COULEE
- RING LEVEES AT FARMSTEADS AND RESIDENCES FROM WEST FARGO TO THE MOUTH OF THE SHEYENNE RIVER
- RESTORATION OF DRAINED WETLANDS, INCREASE STORAGE CAPACITY OF EXISTING WETLANDS, AND/OR PUT CONTROL STRUCTURES ON LEGAL DRAINS FROM FROM BALDHILL DAM TO KINDRED

PHASE I GENERAL DESIGN MEMORANDUM
SHEYENNE RIVER, NORTH DAKOTA
LOCATION MAP
FLOOD CONTROL PLAN D-4
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT JANUARY 1982

PLATE M-6



COMPONENTS OF FLOOD CONTROL

PLAN K-1

- KINDRED DAM (NEAR SITE CAPACITY) (360,000 ACRE-FEET OF FLOOD CONTROL STORAGE)
- REVISED MANAGEMENT OF BALDHILL DAM (INCREASE OF UP TO 14,000 ACRE-FEET OF FLOOD CONTROL STORAGE)

NOTE: FOR ALL PLANS, THE FUTURE BASE CONDITION RECONIZES THAT:

A. ADEQUATE FLOODPLAIN ZONING AND REGULATIONS EXIST AND ARE ENFORCED

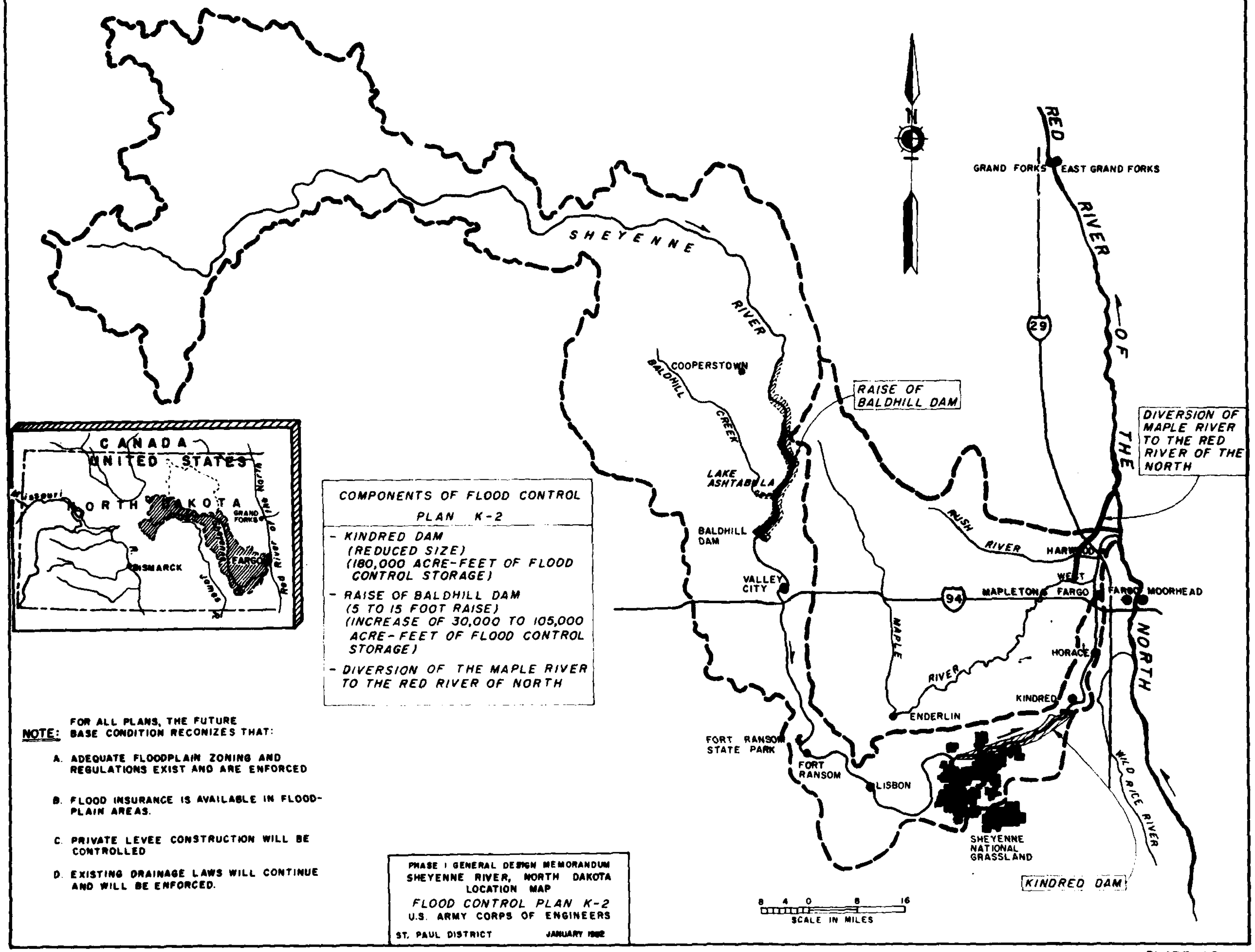
B. FLOOD INSURANCE IS AVAILABLE IN FLOODPLAIN AREAS.

C. PRIVATE LEVEE CONSTRUCTION WILL BE CONTROLLED

D. EXISTING DRAINAGE LAWS WILL CONTINUE AND WILL BE ENFORCED.

PHASE I GENERAL DESIGN MEMORANDUM
SHEYENNE RIVER, NORTH DAKOTA
LOCATION MAP
FLOOD CONTROL PLAN K-1
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT JANUARY 1982

PLATE M-7



COMPONENTS OF FLOOD CONTROL
PLAN K-2

- KINDRED DAM
(REDUCED SIZE)
(180,000 ACRE-FEET OF FLOOD CONTROL STORAGE)
- RAISE OF BALDHILL DAM
(5 TO 15 FOOT RAISE)
(INCREASE OF 30,000 TO 105,000 ACRE-FEET OF FLOOD CONTROL STORAGE)
- DIVERSION OF THE MAPLE RIVER TO THE RED RIVER OF NORTH

NOTE: FOR ALL PLANS, THE FUTURE BASE CONDITION RECONIZES THAT:

A. ADEQUATE FLOODPLAIN ZONING AND REGULATIONS EXIST AND ARE ENFORCED

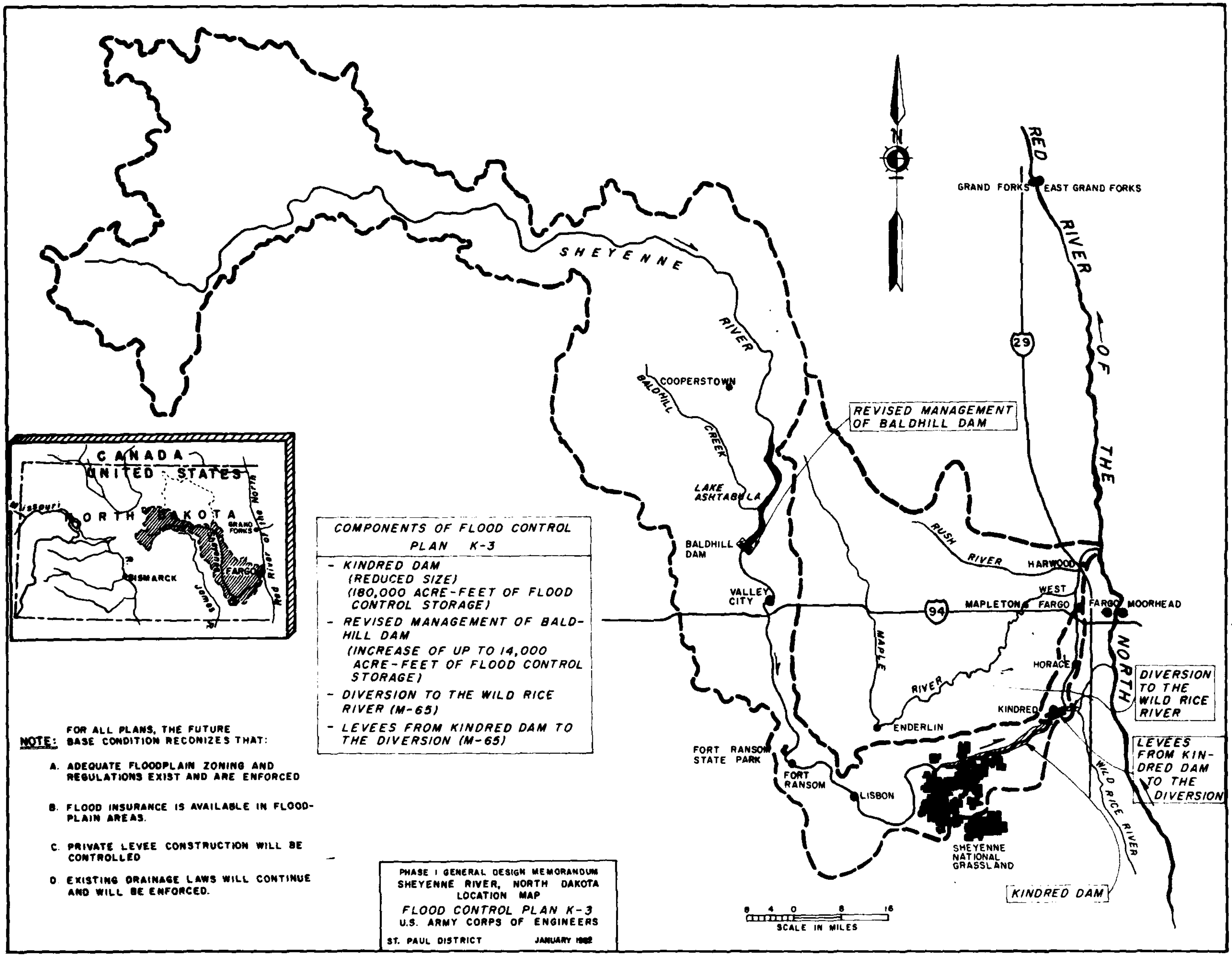
B. FLOOD INSURANCE IS AVAILABLE IN FLOOD-PLAIN AREAS.

C. PRIVATE LEVEE CONSTRUCTION WILL BE CONTROLLED

D. EXISTING DRAINAGE LAWS WILL CONTINUE AND WILL BE ENFORCED.

PHASE I GENERAL DESIGN MEMORANDUM
SHEYENNE RIVER, NORTH DAKOTA
LOCATION MAP
FLOOD CONTROL PLAN K-2
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT JANUARY 1982

PLATE M-8



COMPONENTS OF FLOOD CONTROL PLAN K-3

- KINDRED DAM (REDUCED SIZE) (180,000 ACRE-FEET OF FLOOD CONTROL STORAGE)
- REVISED MANAGEMENT OF BALDHILL DAM (INCREASE OF UP TO 14,000 ACRE-FEET OF FLOOD CONTROL STORAGE)
- DIVERSION TO THE WILD RICE RIVER (M-65)
- LEVEES FROM KINDRED DAM TO THE DIVERSION (M-65)

NOTE: FOR ALL PLANS, THE FUTURE BASE CONDITION RECONIZES THAT:

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B. FLOOD INSURANCE IS AVAILABLE IN FLOODPLAIN AREAS.

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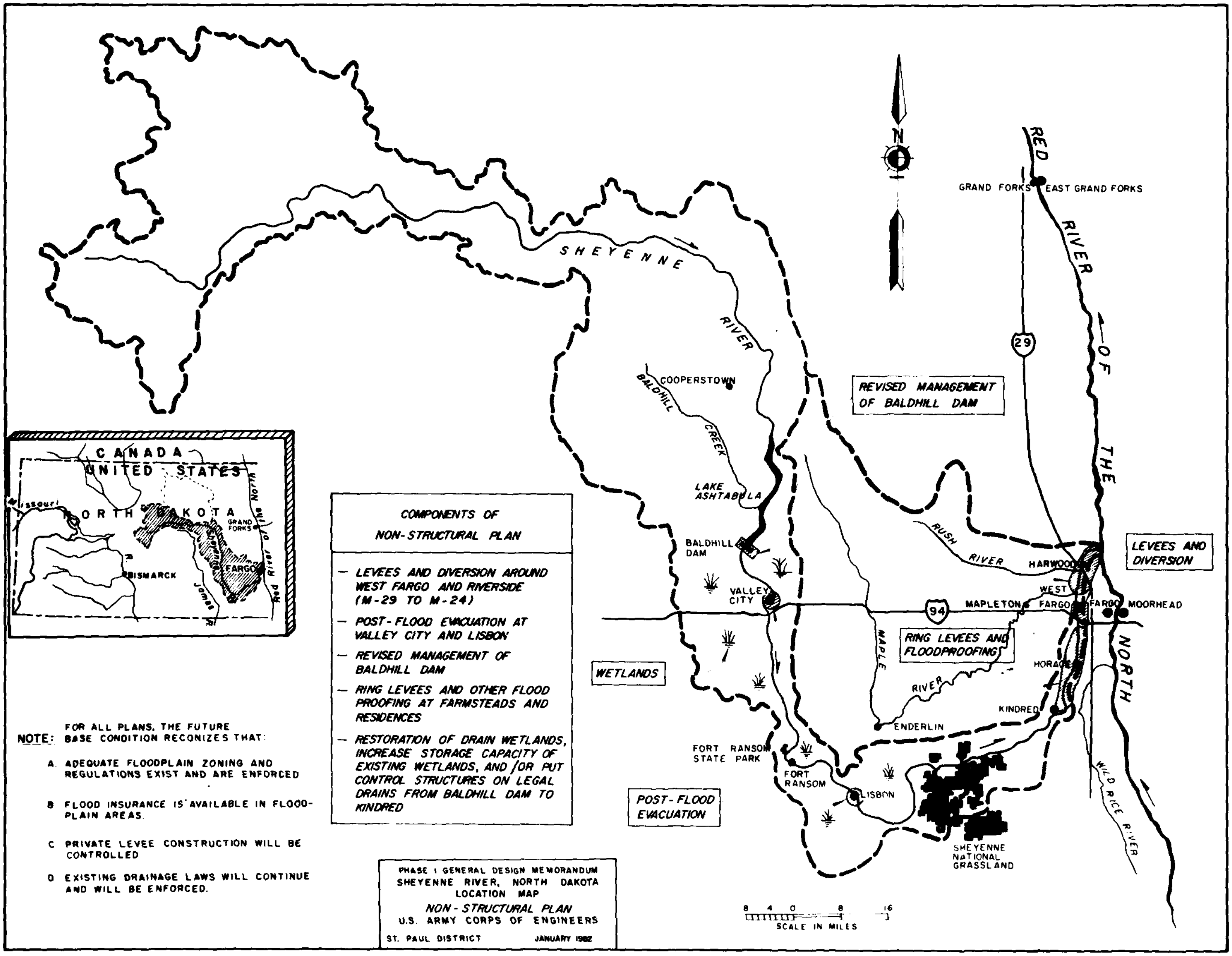
D. EXISTING DRAINAGE LAWS WILL CONTINUE AND WILL BE ENFORCED.

PHASE I GENERAL DESIGN MEMORANDUM
SHEYENNE RIVER, NORTH DAKOTA
LOCATION MAP
FLOOD CONTROL PLAN K-3
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT JANUARY 1982

PLATE M-9


RED RIVER OF THE NORTH
GRAND FORKS
EAST GRAND FORKS
29
N
SHEYENNE
RIVER
COOPERSTOWN
BALDHILL CREEK
LAKE ASHTABULA
BALDHILL DAM
VALLEY CITY
94
MAPLETON
WEST FARGO
FARGO
MOORHEAD
HARWOOD
RUSH RIVER
MAPLE RIVER
HORACE
KINDRED
ENDERLIN
FORT RANSOM STATE PARK
FORT RANSOM
LISBON
SHEYENNE NATIONAL GRASSLAND
WILD RICE RIVER
REVISED MANAGEMENT OF BALDHILL DAM
LEVEES AND DIVERSION
RING LEVEES AND FLOODPROOFING
WETLANDS
POST-FLOOD EVACUATION
CANADA
UNITED STATES
NORTH DAKOTA
Missouri
BISMARCK
James
GRAND FORKS
Red River of the North
COMPONENTS OF NON-STRUCTURAL PLAN
– LEVEES AND DIVERSION AROUND WEST FARGO AND RIVERSIDE (M-29 TO M-24)
– POST-FLOOD EVACUATION AT VALLEY CITY AND LISBON
– REVISED MANAGEMENT OF BALDHILL DAM
– RING LEVEES AND OTHER FLOOD PROOFING AT FARMSTEADS AND RESIDENCES
– RESTORATION OF DRAIN WETLANDS, INCREASE STORAGE CAPACITY OF EXISTING WETLANDS, AND/OR PUT CONTROL STRUCTURES ON LEGAL DRAINS FROM BALDHILL DAM TO KINDRED
NOTE: FOR ALL PLANS, THE FUTURE BASE CONDITION RECONIZES THAT:
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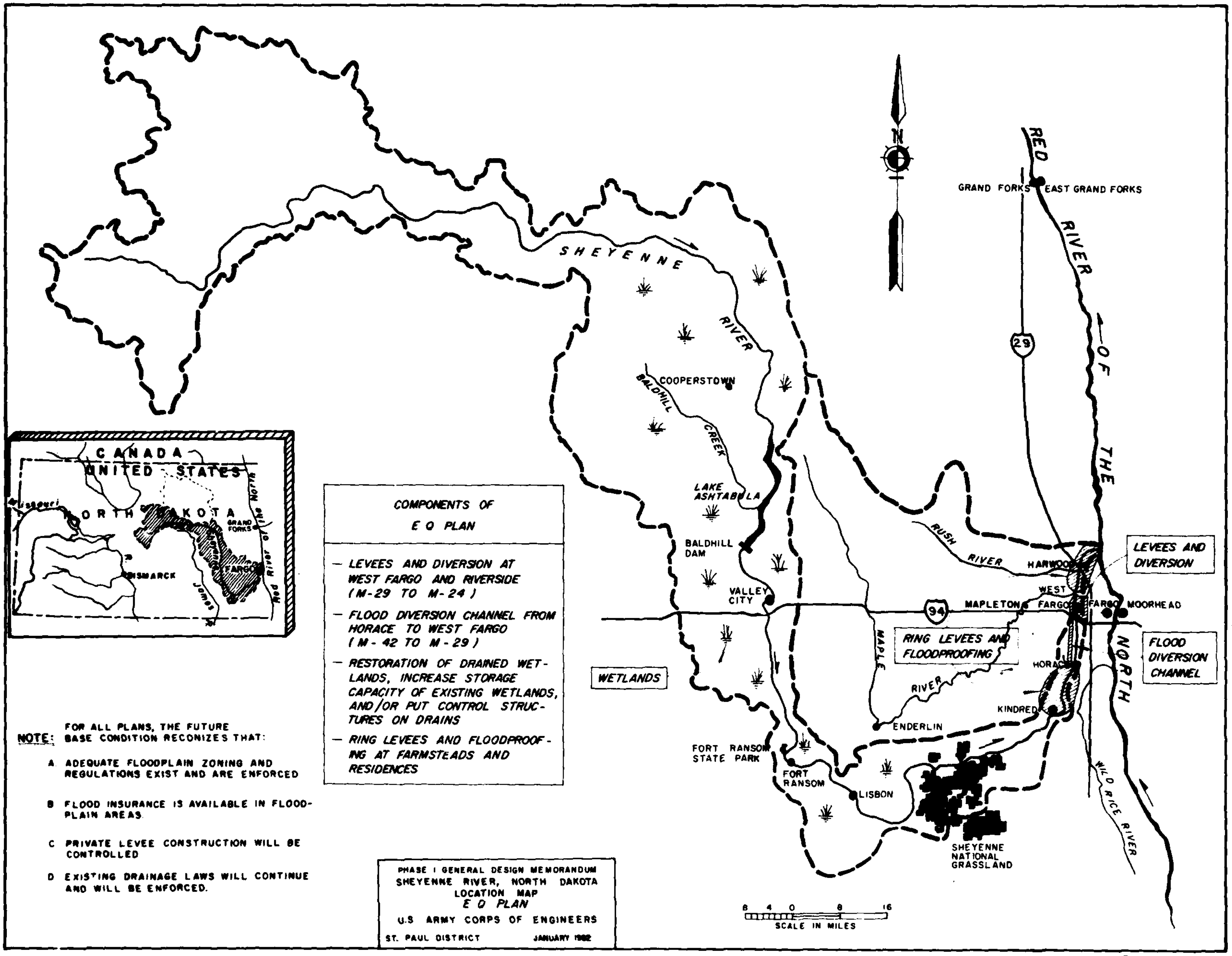
B FLOOD INSURANCE IS AVAILABLE IN FLOOD-PLAIN AREAS
C PRIVATE LEVEE CONSTRUCTION WILL BE CONTROLLED
D EXISTING DRAINAGE LAWS WILL CONTINUE AND WILL BE ENFORCED.
8 4 0 8 16
SCALE IN MILES
PHASE I GENERAL DESIGN MEMORANDUM
SHEYENNE RIVER, NORTH DAKOTA
LOCATION MAP
NON-STRUCTURAL PLAN
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
JANUARY 1982

PLATE M-10



COMPONENTS OF E O PLAN

- LEVEES AND DIVERSION AT WEST FARGO AND RIVERSIDE (M-29 TO M-24)
- FLOOD DIVERSION CHANNEL FROM HORACE TO WEST FARGO (M-42 TO M-29)
- RESTORATION OF DRAINED WETLANDS, INCREASE STORAGE CAPACITY OF EXISTING WETLANDS, AND/OR PUT CONTROL STRUCTURES ON DRAINS
- RING LEVEES AND FLOODPROOFING AT FARMSTEADS AND RESIDENCES

NOTE: FOR ALL PLANS, THE FUTURE BASE CONDITION RECONIZES THAT:

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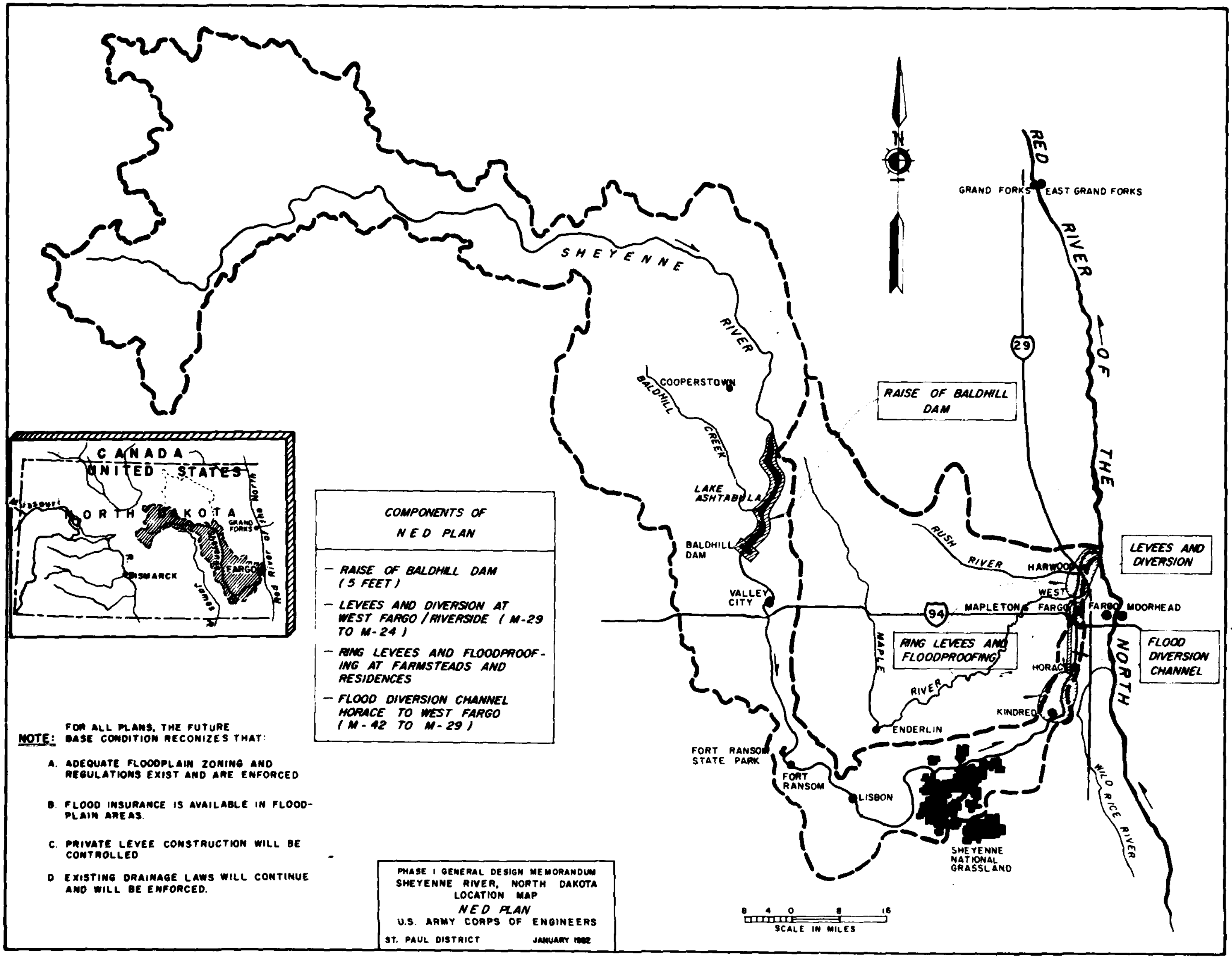
D. EXISTING DRAINAGE LAWS WILL CONTINUE AND WILL BE ENFORCED.

PHASE I GENERAL DESIGN MEMORANDUM
SHEYENNE RIVER, NORTH DAKOTA
LOCATION MAP
E O PLAN
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT JANUARY 1982

PLATE M-11


RED RIVER OF THE NORTH
GRAND FORKS
EAST GRAND FORKS
29
SHEYENNE RIVER
COOPERSTOWN
BALDHILL CREEK
LAKE ASHTABULA
BALDHILL DAM
VALLEY CITY
RAISE OF BALDHILL DAM
RUSH RIVER
HARWOOD
LEVEES AND DIVERSION
WEST FARGO
FARGO
MOORHEAD
MAPLETON
94
RING LEVEES AND FLOODPROOFING
FLOOD DIVERSION CHANNEL
MAPLE RIVER
HORACE
KINDRED
ENDERLIN
FORT RANSOM STATE PARK
FORT RANSOM
LISBON
SHEYENNE NATIONAL GRASSLAND
WILD RICE RIVER
8 4 0 8 16
SCALE IN MILES
CANADA
UNITED STATES
NORTH DAKOTA
Missouri
BISMARCK
James
GRAND FORKS
FARGO
Red River of the North
COMPONENTS OF
NED PLAN
— RAISE OF BALDHILL DAM (5 FEET)
— LEVEES AND DIVERSION AT WEST FARGO / RIVERSIDE (M-29 TO M-24)
— RING LEVEES AND FLOODPROOFING AT FARMSTEADS AND RESIDENCES
— FLOOD DIVERSION CHANNEL HORACE TO WEST FARGO (M-42 TO M-29)
NOTE: FOR ALL PLANS, THE FUTURE BASE CONDITION RECONIZES THAT:
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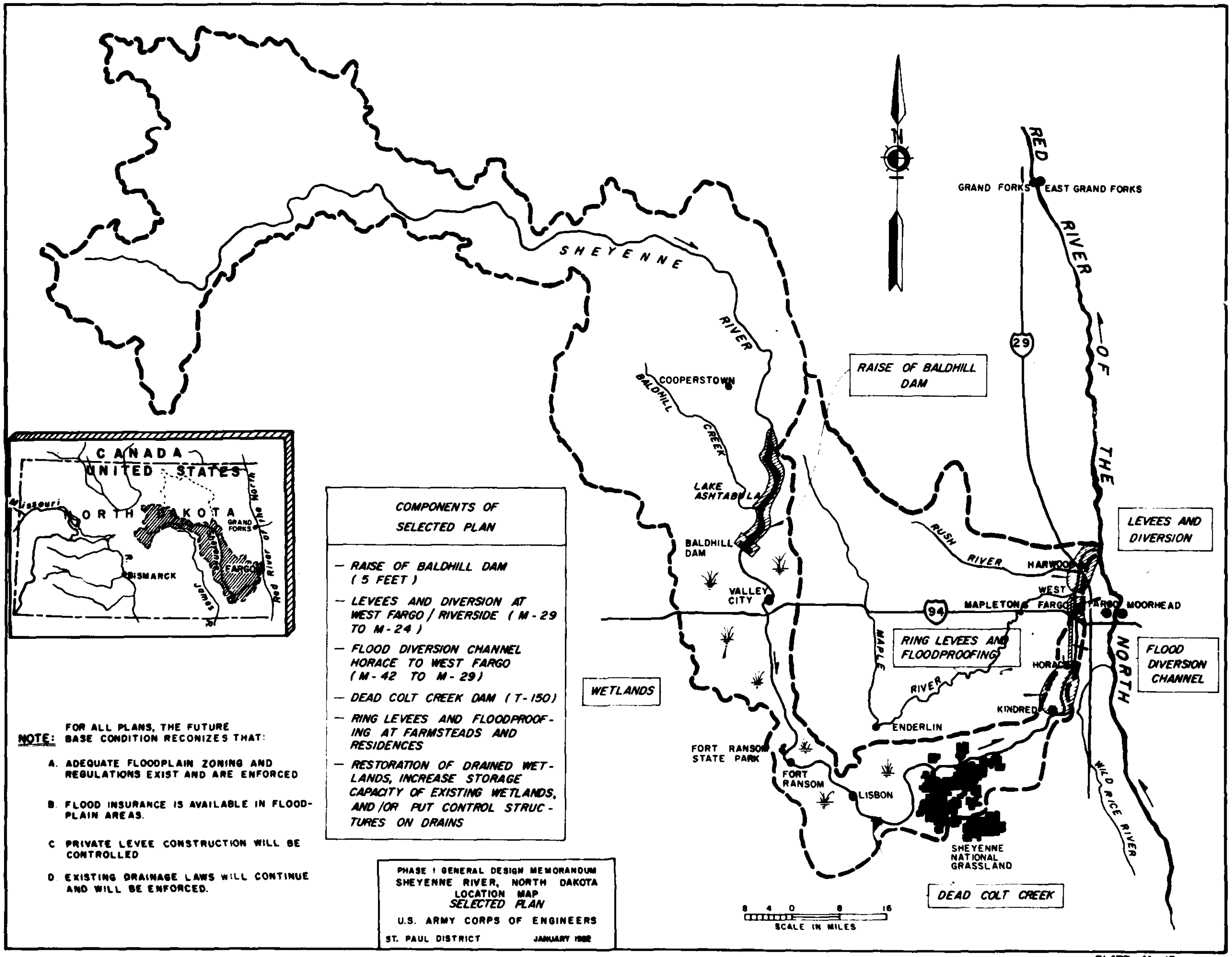
D EXISTING DRAINAGE LAWS WILL CONTINUE AND WILL BE ENFORCED.
PHASE I GENERAL DESIGN MEMORANDUM
SHEYENNE RIVER, NORTH DAKOTA
LOCATION MAP
NED PLAN
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
JANUARY 1982

PLATE M-12



RED RIVER OF THE NORTH
GRAND FORKS
EAST GRAND FORKS
29
SHEYENNE RIVER
RAISE OF BALDHILL DAM
COOPERSTOWN
BALDHILL CREEK
LAKE ASHTABULA
BALDHILL DAM
VALLEY CITY
RUSH RIVER
HARWOOD
WEST FARGO
FARGO
MOORHEAD
MAPLETON
94
LEVEES AND DIVERSION
FLOOD DIVERSION CHANNEL
RING LEVEES AND FLOODPROOFING
MAPLE RIVER
HORACE
KINDRED
ENDERLIN
WETLANDS
FORT RANSOM STATE PARK
FORT RANSOM
LISBON
SHEYENNE NATIONAL GRASSLAND
WILD RICE RIVER
DEAD COLT CREEK
8 4 0 8 16
SCALE IN MILES
N
CANADA
UNITED STATES
NORTH DAKOTA
GRAND FORKS
FARGO
BISMARCK
Missouri
James R.
Red River of the North
COMPONENTS OF SELECTED PLAN
— RAISE OF BALDHILL DAM (5 FEET)
— LEVEES AND DIVERSION AT WEST FARGO / RIVERSIDE (M-29 TO M-24)
— FLOOD DIVERSION CHANNEL HORACE TO WEST FARGO (M-42 TO M-29)
— DEAD COLT CREEK DAM (T-150)
— RING LEVEES AND FLOODPROOFING AT FARMSTEADS AND RESIDENCES
— RESTORATION OF DRAINED WETLANDS, INCREASE STORAGE CAPACITY OF EXISTING WETLANDS, AND/OR PUT CONTROL STRUCTURES ON DRAINS
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D. EXISTING DRAINAGE LAWS WILL CONTINUE AND WILL BE ENFORCED.
PHASE I GENERAL DESIGN MEMORANDUM
SHEYENNE RIVER, NORTH DAKOTA
LOCATION MAP
SELECTED PLAN
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
JANUARY 1982

PLATE M-13

APPENDIX N

FISH AND WILDLIFE COORDINATION ACT REPORT

GENERAL REEVALUATION

AND

ENVIRONMENTAL IMPACT STATEMENT

SHEYENNE RIVER, NORTH DAKOTA

AUGUST 1982

APPENDIX N

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Lower Sheyenne River Study

North Dakota

Fish and Wildlife Coordination Act Report

July 1982

U.S. Fish and Wildlife Service

Bismarck Area Office

Bismarck, North Dakota 58501

EXECUTIVE SUMMARY

In October of 1968 the Corps of Engineers, St. Paul Office, completed an interim survey report on the flooding problems in the Lower Sheyenne River Valley and recommended a large multipurpose reservoir in the vicinity of Kindred, North Dakota. At the time, however, there were some major concerns about the reservoir. These concerns were related to the effects of the reservoir on surrounding ground-water levels (particularly in the Sheyenne National Grasslands, which are administered by the U.S. Forest Service), stability of the side slopes of the reservoir and the effects of reservoir storage on water quality control. Despite these concerns and resistance from environmental groups, Kindred Dam was authorized for construction by Congress in December of 1970.

In 1976, the Corps initiated Phase I GDM studies on the authorized Kindred Dam project. This Phase I GDM was expanded and conducted as a complete reevaluation of the problems and needs in the Lower Sheyenne Basin. In addition, there was a complete reformulation of the alternatives to meet those problems and needs. Over 125 plan elements were developed to help solve flood problems in the Lower Basin. From these plan elements an array of alternatives were developed that would help solve the flooding problems. The basic flood protection measures developed included a levee and flood diversion channel of the Sheyenne River around West Fargo, a flood diversion channel between Horace and West Fargo, a raise of the flood pool of Lake Ashtabula and variations of the authorized Kindred Dam Plan.

As data was generated and evaluated on plan elements and alternative plans, specific elements and combinations of elements began to fall out because of economic, environmental or social considerations. The Kindred Dam alternative eventually dropped from further consideration and only the diversions and a 5-foot raise of the flood pool in Lake Ashtabula were carried forward.

The major features of the Selected Plan are levees and a flood diversion channel of the Sheyenne River around West Fargo, a flood diversion channel of the Sheyenne River from Horace to West Fargo and a 5-foot raise of the flood pool at Lake Ashtabula.

Basically, there is minimal environmental impacts from the diversion channels. They either follow existing drainageways or are routed through cropland. A raise of Lake Ashtabula has some negative environmental effects but mitigation can be achieved through either the purchase of 450 acres of existing habitat or managing project lands around the reservoir. The Baldhill Dam National Fish Hatchery will be seriously impacted by the loss of 11 rearing ponds and the hatchery building with a raise of Baldhill Dam. The facilities would be replaced as a part of the project, or by upgrading of Baldhill Dam through the National Dam Safety Program.

Overall, the Selected Plan, when implemented, properly, would only have a negligible impact on fish and wildlife resources and other environmental values.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
AREA OFFICE—NORTH DAKOTA
1500 CAPITOL AVENUE
[redacted]
BISMARCK, NORTH DAKOTA 58501

JUL 2 8 1982

Colonel Edward G. Rapp, District Engineer
St. Paul District, Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Colonel Rapp:

This Fish and Wildlife Report provides an assessment of the Lower Sheyenne River Study, North Dakota. This report is to accompany the Corps of Engineers Report to Congress. It has been prepared under the authority of and in accordance with the provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.). It is also consistent with the intent of the National Environmental Policy Act of 1969 (P.L. 91-190; 83 Stat. 852-856). It addresses the effects of the various alternative plans on fish and wildlife resources, and conveys recommendations which are designed to prevent, mitigate or compensate adverse effects to these resources. This report supersedes our Coordination Act Report of October 6, 1966. Comments on the conclusion and recommendations of this report by the North Dakota Game and Fish Department (NDGFD) are contained in the attached letter dated July 22, 1982, signed by Commissioner Dale L. Henegar.

Section 7(c) of the Endangered Species Act, 87 Stat. 884, as amended, requires that your agency ask the Secretary of the Interior, acting through the U.S. Fish and Wildlife Service, whether any listed or proposed endangered or threatened species may be present in the area of each federal construction project. The Corps initiated a Section 7 consultation with the Service that covered the peregrine falcon (Falco peregrinus) bald eagle (Haliaeetus leucocephalus) and the Dakota skipper (Hesperia dacotae). After reviewing the Corps' biological assessment, the Service agreed that none of the alternatives would affect bald eagles or the peregrine falcon, but the Kindred Dam alternative would likely affect the Dakota skipper. The Dakota skipper, however, has been removed from the proposed species list.

A Department of the Army permit, issued pursuant to Section 404 (P.L. 92-500) and Section 10 of the Rivers and Harbors Act of 1899, may be required for the placement of fill material into the Sheyenne River for the construction of the diversions or placing a dam on Dead Colt Creek. A final Environmental Impact Statement (EIS) for a federal project must be submitted to Congress before the discharge of dredged or fill material into waters of the United States, and prior to either authorization of the project or an appropriation of funds for such construction. The EIS must cover all issues that are similarly addressed in the application of a Section 404 permit.

In the view of the Service, the Corps of Engineers is in compliance with Executive Order 11988, Floodplain Management, and Executive Order 11990, Protection of Wetlands, for construction of the Selected Plan. While construction takes place on the Sheyenne River floodplain and does involve wetlands, wildlife habitat and other environmental values should not be seriously affected provided mitigation recommendations are accepted and implemented.

Our recommendations and associated costs for mitigating and compensating project-induced fish and wildlife losses are consistent with the Presidential Directive (of June 1978) on environmental quality and water resources management. That directive states:

> In all project construction appropriation requests, agencies shall include designated funds for all environmental mitigation required for the project and shall require that mitigation funds be spent concurrently and proportionately with construction funds throughout the life of the project.

DESCRIPTION OF THE AREA

The Sheyenne River Basin, 7,320 square miles in size, is part of the Red River of the North drainage. Originating in Sheridan County, North Dakota, the Sheyenne flows 568 miles through 16 counties before entering the Red River 10 miles north of Fargo. The average gradient along its length is 1.5 feet per mile. The three main tributaries of the Sheyenne River are Baldhill Creek, Maple River and Rush River. The only major impoundment on the Sheyenne is Lake Ashtabula (pool capacity 70,000 acre-feet). Sheyenne River flows are variable. The maximum flow at Kindred for the 30-year period of record was 4,690 and the minimum flow was 13 cfs.

Approximately 70 percent of the land in the Sheyenne Basin is cultivated. While wheat is the principal crop, corn, sunflowers and alfalfa are becoming more common. Livestock production is intensive and feedlots are common through the entire valley. Annual precipitation in the Sheyenne Basin averages 18.15 inches. Flooding, caused largely by snow melt, occurs in the late winter and early spring. Highest monthly precipitation is in June with an average of 3.5 inches. The growing season averages 122 days. Glacial till soils characterize the Red River Valley lands and portions of the Sheyenne Basin above Valley City. These lands are farmed extensively. The mid-section of the basin between the towns of Kindred and Valley City is sandy and subject to considerable wind erosion.

There are many state and federal fish and wildlife areas in the Sheyenne Valley. Most prominent are the Valley City and Baldhill Dam National Fish Hatcheries (administered by the U.S. Fish and Wildlife Service) and the Sheyenne National Grasslands (administered by the U.S. Forest Service). An important state area is the Mirror Pool Wildlife Management Area (WMA).

DESCRIPTION OF THE PROJECT

Although the Selected Plan contains six separate elements, only the first three have a probability for federal involvement through the Corps of Engineers. The remaining three elements have the greatest probability for implementation through other federal programs or through nonfederal interests. Should any of the last three plan elements be implemented through other federal programs, we would then become again involved in these projects and provide technical input as needed.

The Selected Plan contains these major features:

* Levees and diversion of the Sheyenne River around West Fargo (M-30 to M-24).

* A flood diversion channel of the Sheyenne River from Horace to West Fargo (M-42 to M-30).

* A 5-foot raise of the flood pool in Lake Ashtabula.

* Wetland restoration (includes on land water storage, control of legal drains and increasing floodwater storage capacity of existing wetlands).

* Tributary dam at Dead Colt Creek.

* Ring levees at farmsteads and residences from Kindred to Horace and West Fargo to the Red River.

The Selected Plan features levees around West Fargo/Riverside capable of providing protection from occurrence of a standard project flood, plus a flood diversion channel. In addition, another flood bypass channel would be constructed from Horace to West Fargo capable of carrying 1,700 cfs. The management of Bladhill Dam would stay at the same conversion pool elevation (1,266 feet), but 5 feet of flood pool would be added (elevation 1,271 feet).

Drained wetlands would be restored and the capacity of existing wetland could be increased. A multipurpose dam on Dead Colt Creek would be constructed by the North Dakota Water Commission. Ring levees around farmsteads and residences would be constructed by the Soil Conservation Service, state and local entities, from Kindred to Horace and from West Fargo to the Red River.

Evaluation Methodology

The primary method used to evaluate wildlife habitat associated with the various alternative plans was the Habitat Evaluation Procedures (HEP), revised March 1976. The Corps of Engineers, NDGFD and the Fish and Wildlife Service (FWS) participated in the development of the HEP data used in project analysis.

HEP takes a habitat approach to impact assessment and provides a method of describing baseline conditions and predicting future habitat conditions in terms of habitat quality and quantity. This is accomplished by inventorying baseline conditions and predicting and analyzing land-use impacts on wildlife habitat and carrying capacity. The Habitat Suitability Index (HSI) is the basic parameter used in habitat evaluation to describe habitat quality. The HSI for a species is assumed to be proportional to the carrying capacity of the habitat for that species (evaluation element). The product of the HSI (habitat quality) and the area of the cover type (habitat quantity) is the Habitat Unit.

Habitat evaluation of project impacts is based on this preliminary data from: (1) present land-use and project land-use changes; (2) engineering designs relevant to the alternative project plans; (3) areas of various cover types; and (4) baseline data on existing habitat quality and quantity.

Individual species are selected for each cover type and used as evaluation elements in the determination of habitat quality. The final list of evaluation elements developed for the Lower Sheyenne River Study includes species that were: (1) economically important; (2) of high public interest; (3) good indicators of habitat quality; and/or (4) of particular interest due to restricted range, high vulnerability or unique habitat requirements.

In most instances, species were selected that occupied a wide variety of niches. In selecting birds for the various habitat types, Stewart's "Breeding Birds of North Dakota" has a good species list for the habitats. Key mammal species were similarly selected from other lists and references.

Once the key species were selected, a handbook was developed that contained the life requirements of these species (the handbook is available in the Bismarck Area Office). The material for this handbook came from literature searches, scientific abstracts and publications on the selected species. This material was taken to the field and the habitat types evaluated were compared with the species criteria and rated accordingly. A 0 to 1 scale was used with 1 representing optimal habitat. The suitability of a terrestrial cover type for a particular species was determined by observing various habitat characteristics and determining the degree to which they met the life requirements of the species being evaluated. The habitat characteristics utilized were those that are important to the survival and well-being of the species, including: (1) cover type criteria that relate directly to the life requisite needs provided by the cover type; (2) interspersion criteria that measure the spatial relationships between the cover type being sampled and other cover types that are also necessary to meet life requisite needs of the evaluation elements; and (3) criteria such as noise and other human disturbance factors.

Losses in the flood pool of Lake Ashtabula were calculated on the basis of frequency of inundation, duration of flooding, time of flooding and location of habitat types in the flood pool. This procedure was adapted from a report by the Environmental Resources Branch, Corps of Engineers, St. Paul, entitled "Assessment of Flood Damages Due to Flooding: A Proposed Methodology". Using this procedure, we were able to calculate the average annual habitat losses in habitat units.

For the purpose of our evaluation, the team assumed that without the project there would be no change in deciduous hardwoods or wetland habitat in the immediate project area. The team also assumed that cropland would change to old field in the period of time it takes for the land to be purchased and the dam constructed. In that interim period, the value of the cropland would be reduced to zero, but as grassland it would begin to rise in value until the first flood event. These habitat types were combined because of the similar habitat characteristics they would have at the first flood event. Also the key species were similar for both habitat types and the HSI for cropland and grassland were essentially the same.

After evaluating each sample site of a given habitat type, the scores were added for each species and divided by the number of sample sites. This gave an average HSI value for that particular species. These species values were then added together and divided by the total number of species. This yielded an average HSI value for that particular habitat type. That value is the basis of all future calculations.

For example, the HSI of deciduous hardwoods was .60 in the raise of the Lake Ashtabula alternative. When .60 was multiplied by the total hardwood (170) acres affected, the product was in habitat units (102). At this point we developed a management increment for the existing woodlands. Basically, this is the difference between the value of the existing habitat and maximum value of the habitat if it were intensively managed for wildlife. At Lake Ashtabula the maximum potential value of the habitat was .85. It is .85 rather than one (1) because intensive management for one species would be at the expense of one or more species. As a result, even though it is possible to achieve a rating of one (1) for individual species when these values are pooled and divided by the number of elements for each habitat type, the value will generally be less than one (1). In this case the management increment is .25 (.85-.60). The total number of average annual habitat units lost (this is a function of flood frequency duration) divided by the management increment, yields the total acres of existing habitat that are needed to compensate the habitat lost. This method of evaluation assumes that existing habitat will be used to replace losses.

FISH AND WILDLIFE RESOURCES WITHOUT THE PROJECT

A detailed description of fish and wildlife resources in the Sheyenne Basin was transmitted to the Corps of Engineers in a report dated November 19, 1980. Since a 5-foot raise of the flood pool in Lake Ashtabula, and diversions of the Sheyenne River around West Fargo and from Horace to West Fargo are all that are being considered for the Corps' involvement in the Selected Plan, our discussion will be limited to those plan elements.

Aquatic Resources. Lake Ashtabula provides a diverse fishery for the area anglers. While walleyes, northern pike and muskellunge offer a good sport fishery, yellow perch, white bass and black bullheads are the dominant species harvested. Since 1953, Lake Ashtabula has supported a sporadic commercial fishery for black bullheads, white suckers and yellow perch. Fish from Lake Ashtabula annually provide the source of about 14,000,000 northern pike and 10,000,000 walleye eggs for the Valley City National Fish Hatchery. Fish produced from these eggs are stocked in Lake Ashtabula as well as other lakes both in North Dakota and other states.

The fishery at Lake Ashtabula can be expected to decline slightly in the future if unregulated wetland drainage and feedlot effluent continue. These conditions hasten eutrophication. Lake Ashtabula has already been characterized as having the poorest water quality of any major impoundment in the state. Continual adding of nutrients can only worsen an already bad situation. In the winter of 1978-79, partial winterkill occurred in the lake due to low oxygen levels. The additional nutrients and resultant poor water quality will create unfavorable conditions for continued fish survival. Total winterkill can be the result if water quality continues to decline and low oxygen levels occur.

The NDGFD survey indicate the yearly average angler use for Lake Ashtabula from 1969 to 1975 was 45,068 days or about 50 percent of the total angling effort in the state. Although highly variable, winter ice fishing comprises about 15 percent of the total angling effort in the lake.

Terrestrial Resources. Although some good wildlife habitat exists around the margin of Lake Ashtabula, a majority of it is of medium to low value for wildlife. This is due primarily to recreational development and intensive grazing. This habitat corresponds to Resource Category No. 4 as described in the Fish and Wildlife Service Mitigation Policy. The habitat is of medium to low value for the evaluation species.

Five broad habitat types were identified in the Lake Ashtabula area. They were woodlands, shrublands, grasslands and croplands, and wetlands. Representative wildlife are listed in Table 1.

Table 1 contains a list of key species that were used to evaluate the habitat. As described in the "Evaluation Methodology" section, species selection was based on their dependence of that habitat type.

Table 1: Key Species List By Habitat Type

Hardwoods	
White-tailed Deer	Odocoileus virginianus
Fox Squirrel	Sciurus niger
Least Flycatcher	Empidonax minimus
Downy Woodpecker	Picoides pubescens
Red Fox	Vulpes fulva
Great Horned Owl	Bubo virginianus
Cooper's Hawk	Accipiter cooperii
Raccoon	Procyon lotor
Shrubland	
Bullsnake	Pituphis melanoleucus
Brown Thrasher	Toxostoma rufum
Gray Catbird	Dumetella carolinensis
Red Fox	Vulpes fulva
Long-tailed Weasel	Mustela frenata
Grasshopper Mouse	Onychomys leucogaster
American Goldfinch	Carduelis tristis
Meadow Vole	Microtus pennsylvanicus
White-tailed Deer	Odocoileus virginianus
Gray Partridge	Perdix perdix
Grassland	
Red Fox	Vulpes fulva
Meadowlark	Sturnella neglecta
White-tailed Deer	Odocoilues virginianus
Prairie Vole	Microtus ochrogaster
Mallard	Anas platyrhynchos platyrhynchos
Eastern Kingbird	Tyrannus tyrannus
Pintail	Anas rubripes
Savannah Sparrow	Ammodramus sandwichensis

Cropland

Gray Partridge	Perdix perdix
Meadowlark	Sturnella neglecta
Mourning Dove	Zenaidura macroura
Red Fox	Vulpes fulva
White-footed Mouse	Peromyscus leucopus
Grasshopper Mouse	Onychomys leucogaster
Vesper Sparrow	Pooecetes gramineus

Wetland

Marsh Hawk	Circus cyaneus
White-tailed Deer	Odocoileus virginianus
Mallard	Anas platyrhynchos platyrhychos
Pintail	Anas rubripes
Red Fox	Vulpes fulva
Long-tailed Weasel	Mustela frenata
Mink	Mustela vison

Woodlands - This habitat type could more accurately be described as wooded pasture since this is the primary use. The 170 acres of this habitat type comprises about 14 percent of the habitat at the 1271 msl contour elevation. Primary tree species are green ash (Fraxinus pennsylvanica), boxelder (Acer negundo), American elm (Ulmus americana) and basswood (Tilia americana). In this habitat type, the understory was sparse and ground cover was limited to bluegrass, thistle, milkweed and stinging nettle. Generally the wooded areas were limited to the upper end of the reservoir.

Wetlands - This habitat type was very common and occurred in a 5 to 10 foot fringe around the upper end of the reservoir, in the draws entering the reservoir and a large marsh at the upper end of the conservation pool. It was the most common habitat type and comprised about 563 acres or 46 percent of land to elevation 1271 msl. Plant species consisted primarily of cattail (Typha sp.), bulrush (Scirpus sp.) and cordgrass (Spartina sp.). Much of the wetland fringe had been trampled or eaten by livestock. Usually heavily grazed pasture bordered the wetlands.

Grassland - Grasslands in the project area are used primarily for pasture. This was the second most common habitat type and comprises 474 acres or 39 percent of the land to elevation 1271 msl. Bluegrass accounted for as much as 90 percent of the plant composition. Other plants such as milkweed (Asclepias syriaea), leadplant (Amorpha canescens), sage (Artemisia sp.), wheatgrass (Agropyron smithii), goldenrod (Solidago altissima), and leafy spurge (Euphorbia esula) are common. Other prairie type plants like coneflower (Ratibida sp.), blue gramma (Bouteloua gracilis) and big blue stem (Andropogon gerardi) are not uncommon. Intensive grazing to the point of overgrazing is common in this area. It gave the grasslands (pasture) a golf course type appearance. Although cropland was evaluated, this was combined with grassland since cropland (about 15 percent of the total area) would change to grassland (old field) if the project were constructed.

Shrubland - This habitat type occurred in scattered patches throughout the project area. Most could be described more accurately as shrub draws or hillside. This type comprised approximately 1 percent of the total habitat to 1271 msl. Where this type did occur, it provided good quality habitat for wildlife. A majority of the shrub patches occurred in odd corners or on an isolated hillside, thus cattle had not degraded them.

Common plant species include chokecherry (Prunus virginiana), buffaloberry (Shepherdia argentea), black ash (Fraxinus nigra), juneberry (Amelanchier sp.), honeysuckle (Lonicera sp.), and a good mixture of prairie grasses and herbaceous plants.

Data in Table 2 contains the habitat types, acreages, HSI and average annual equivalent losses in HU's and acres for a 5-foot raise of the flood pool at Lake Ashtabula. All habitats rated average or slightly below for the species we evaluated. No net changes in habitat or habitat values are anticipated in the future. Conversion of grasslands or woodlands to cropland will probably not occur because of the topography of the area.

Table 2: 5-foot Raise of the Flood Pool at Lake Ashtabula

Habitat Type	Total Acres of Habitat Available	H.S.I. Value	Habitat Units	Average Ann. Equiv. Loss in HU's	Average Ann. Equiv. Loss in Acres
Woodlands	170	.60	102	73	122
Grasslands	474	.36	171	68	189
Shrublands	7	.61	4	1	2
Wetlands	563	.54	304	0	0
TOTALS	1,214		581	142	313

The NDGFD also has set up some waterfowl rest areas with landowners along the reservoir. The size of these can vary from year to year, but basically provide refuge for migrating waterfowl during the fall hunting season.

Habitat data obtained in the HEP analysis came from wide ranging locations in the Sheyenne Basin. Making a general comparison, the woodland and grassland habitat rated much lower around Lake Ashtabula than anywhere else in the basin. While woodlands in North Dakota comprise only about 1 percent of the total land area in the state, they provide essential habitat for many wildlife species.

EVALUATION OF ALTERNATIVE PLANS

Since 1976, the Service has been involved in a continuing evaluation of the Lower Sheyenne River Study. Basically, this involved the evaluation of over 125 plan elements that were developed as potential solutions to the flood problems in the Lower Basin. Only a large raise (10-25 feet) of Lake Ashtabula, Kindred Dam, a tributary dam on Dead Colt Creek and Timber Coulee were likely

to have adverse impacts on fish and wildlife resources. Although the Kindred Dam and Timber Coulee Dam were subsequently dropped from further consideration, they bear mentioning here because of their importance throughout the entire evaluation.

Lake Ashtabula - Orginally evaluated as a much larger raise (10 to 25 feet) this was subsequently scaled down because of social, economic and environmental considerations. A raise of 25 feet in the flood pool would cause relocations of all of cabins and public campgrounds would be flooded and 5,500 acres of wildlife habitat would have been adversely affected. Mitigation requirements would have been about 3,500 acres.

Kindred Dam - Authorized as a multiple-purpose project with a permanent pool, the Kindred Dam was later evaluated as a flood control structure (dry dam). The elevation at the bottom of the dam was 930 msl and the top was 1015 msl. Approximately 9,000 acres of wildlife habitat would have been affected by this proposal. It made little difference in the quantity of habitat affected between the wet (permanent pool) and dry dam proposals since the inundation period in the dry dam still destroyed much of the vegetation, especially at the lower elevations.

Over 4,000 acres of the habitat being affected was hardwoods. Mitigation for habitat loss was approximately 7,000 acres. About 6,000 acres of mitigation was needed for hardwood (woodland) replacement alone. Since the best woodlands in the Sheyenne Basin would have been destroyed, finding suitable replacement habitat was difficult. It was calculated that all remaining woodlands in the lower basin would have to be protected and managed for wildlife if an equitable mitigation plan was implemented that covered all woodland losses.

In addition, the Mirror Pool WMA (547 acres), which is managed by the NDGFD, would have been lost to the project. This area is unique for two reasons. The primary one being that it contains a series of spring fed ponds in the midst of a contiguous stand of hardwoods. This unique combination of habitats is not duplicated anywhere else in the state. The second feature of this area is that it is controlled by the NDGFD and dedicated to wildlife management. Any riverine habitat in public ownership is rare along the Sheyenne River. In addition, many plant and animal species found in this area are not found anywhere else in the state.

The federally managed Sheyenne National Grasslands could potentially be affected by a raise of ground water in the vicinity of Kindred Dam. Some upland habitat would be changed to a sedge-wet meadow community. Composition of animal species would likewise change.

The Kindred Dam alternative was the most environmentally damaging of any alternative studied.

Timber Coulee and Dead Colt Creek - Small flood control dams on tributaries to the Sheyenne River were originally envisioned. Local groups later requested that the dam on Dead Colt Creek be multipurpose with a permanent pool.

Table 3: The relationship of the plan elements to the NED, EQ and Selected Plans.

Plan Elements	NED	EQ	Selected Plan
Levees and diversion at West Fargo/Riverside.	X	X	X
Floodway/diversion from West Fargo to Horace.	X	X	X
Raise Baldhill Dam 5 feet.	X		X
Multiple-purpose reservoir at Dead Colt Creek.			X
Ring levees at farmsteads and residences from Kindred to the mouth of the Sheyenne River.	X	X	X
Restore drained wetlands and increase the size of existing wetlands in the basin between Baldhill Dam and Kindred, including onland storage and control of legal drains (selected wetland areas only).		X	X
Flood-plain regulations.	X	X	X
Floodproofing.		X	X
Flood warning and forecasting.	X	X	X
More stringent control on private levee construction.	X	X	X
More stringent control on drainage.	X	X	X
Grassed waterway in and along the diversion channel.		X	X
Shelterbelts at selected locations along the diversion channel.		X	X
Control grazing and cattle access at Lake Ashtabula.		X	X
Investigate construction of subimpoundments at Lake Ashtabula.		X	X
Investigate use of aerators at Lake Ashtabula.		X	X
Where practical, encourage public landownership/easement of riverine lands through programs such as state or federal wild, scenic and recreational rivers designation or development of state parks or forests, etc., for suitable reaches of the Sheyenne River.		X	X
Encourage the use of more land treatment measures in the watershed, including stock ponds, shelterbelts, conservation, tillage, etc.		X	X
Revised management of Baldhill Dam.	X		
Emergency flood protection measures at Valley City and Lisbon.		X	
Flood insurance made available.		X	
Investigate low flow augmentation downstream of Lake Ashtabula for fishery and water quality.		X	
Flood emergency plans.	X		

Dead Colt Creek and Timber Coulee are intermittent streams that do not support any fishery. At the elevations of 1155 and 1160, they would inundate 340 acres and 238 acres, respectively, of low value wildlife habitat.

Timber Coulee has been dropped from further consideration and the ND State Water Commission is working with local supporters of the Dead Colt Creek plan.

Development of NED and EQ Plans

After all plan elements were evaluated, various alternatives were developed as solutions to the flood problems in the Lower Sheyenne Basin. Through changes and refinement, parts of the alternatives became the National Economic Development (NED) Plan, Environmental Quality (EQ) Plan and Selected Plan. Table 3 contains a complete array of plan elements that comprise the NED, EQ and Selected Plans.

The first three plan elements in Table 3 have the greatest probability of implementation through the Corps of Engineers. The next three plan elements have some flood control benefits, but would not be constructed by the Corps. The remaining plan elements have some value in reducing flood losses or have beneficial environmental effects, but the Corps is recommending these to other federal or nonfederal interests for implementation. All are helpful in reducing floods.

EFFECTS OF THE SELECTED PLAN ON FISH AND WILDLIFE RESOURCES

The major plan elements of the Selected Plan are contained in Table 4. This table shows the effect of each element on fish and wildlife resources. While federal involvement through the Corps of Engineers will be limited to the first three elements, our evaluation will consider the effects of all the plan elements.

Table 4: Effects of Selected Plan on Fish and Wildlife Resources

Plan Elements	Habitat Acres Affected	Stream Miles Affected	Mitigation
Levee & Diversion Around West Fargo (M-30 - M-24)	Little	None	No
Floodway & Diversion Horace to West Fargo (M-24 - M-30)	Little	None	No
Flood Pool Increase at Lake Ashtabula (5 feet)	1,214	5	Yes
Tributary Dam at Dead Colt Creek	340	1	Yes
Wetland Restoration	None	None	No
Ring Levees at Farmsteads and Residences from Kindred to the Red River.	None	None	No

Fish. The only two plan elements that could affect fishery resources are the tributary dam on Dead Colt Creek and a raise of the flood pool at Lake Ashtabula. Our evaluation indicates there would be little impact on the fishery from either of these plan elements. Dead Colt Creek is an intermittent stream, thus there is little usable fishery habitat at present. In fact, there is the potential for creating a viable fishery in the permanent pool. This would provide positive fishery benefits. At Lake Ashtabula, a minor change in the flood pool will not appreciably change the fishery since the conservation pool will remain the same. There is the potential for the raise to have a minor positive effect on the fishery. Inundated vegetation provides optimal spawning habitat for northern pike. However, this period of inundation needs to be for at least 30 days in order to be of some benefit. This allows time for the eggs to hatch, absorb the yolk sac and then begin to actively feed and respond to changes in their environment (water drawdowns). A shorter period of inundation would kill eggs and fry.

There is also the potential for minor adverse effects to the fishing in Lake Ashtabula from this alternative. During extended periods of inundation, wave action can cause erosion of the shoreline and loss of bankline vegetation. The turbid conditions that result could be detrimental to fish eggs that were deposited in near shore areas in the spring. The silt can smother both fish eggs and fry. This would primarily affect walleyes and northern pike.

A 5-foot raise of the flood pool in Lake Ashtabula will require modifications of Baldhill Dam. These modifications could also be part of the Dam Safety Program. If and when these modifications are made, they will require extra land on the downstream side of Baldhill Dam in the vicinity of the Baldhill Dam National Fish Hatchery.

Eleven of the rearing ponds at the hatchery and a building would be affected by renovation of the dam. These ponds are important to the overall fishery program in North Dakota. Walleye and northern pike are stocked in these ponds and then harvested as fingerlings. Fish from this facility are stocked not only in Lake Ashtabula but other North Dakota waters as well. The Service has long-range commitments with not only the State of North Dakota but also other federal agencies such as the Bureau of Indian Affairs for the fish that come from these ponds. As such, interruption of our hatchery program or reduced availability of fish will have far reaching impacts.

Another impact of the modification of Baldhill Dam is the loss of a hatchery building. This 30 x 60 foot cement block building is used to house fish holding tanks, hatchery equipment and food used in pond culture. The holding tanks and storage area are essential in the efficient operation of this facility.

Wildlife. In the Selected Plan, the only two plan elements that affect wildlife habitat to a major degree are the tributary dam at Dead Colt Creek and a 5-foot increase in the flood pool of Lake Ashtabula. Since the Corps would not be involved in the construction of a tributary dam on Dead Colt Creek our involvement would be very limited. If another federal agency became involved in the implementation of this element, a mitigation plan would be developed under a separate authority.

A 5-foot raise of the flood pool at Lake Ashtabula will have a negative effect on wildlife habitat. A maximum of 1,214 acres would be periodically inundated. Refer to Table 2 for the types and amount of habitat affected.

In addition, wave action in the flood pool can cause shoreline erosion and loss of vegetation along the shoreline. Both factors are dependent on time of flooding, duration and height of the flood pool.

The most important habitat type affected is woodlands, which is located at the extreme upper end of the reservoir. These woodlands provide habitat for many species of wildlife. Deer use the woodlands in the winter for food and cover. The scarcity of cover in the uplands make the wooded areas especially valuable. Raptors, including the great horned owl and red-tailed hawk, nest and hunt in the valley and surrounding farmland. The woodlands also provide habitat for songbirds and provide migratory habitat for numerous passerine species.

DISCUSSION/MITIGATION

The three plan elements that will require federal involvement through the Corps of Engineers are:

* Levee and diversion around West Fargo.

* Diversion from Horace to West Fargo.

* A 5-foot raise of the flood pool at Lake Ashtabula.

With either of the first two elements, there are minimal impacts to fish and wildlife resources. Existing drainageways and cropland will be the primary land uses for project development, thus no mitigation is required.

The raise of the flood pool elevations in Lake Ashtabula, will cause adverse effects to fish and wildlife resources. The effects of the raise and the mitigation requirements are contained in the following discussion.

Aquatic Resources. Turbidity caused by erosion will be temporarily created around the fringe of the reservoir during flooding events. Since this turbidity would partially result from a 5-foot raise in the level of Lake Ashtabula, measures should be implemented to those parts of the shoreline that would be most susceptible to wind and wave action during high-water periods. Rock riprap could be used, but vegetative plantings may also work. Another alternative would be to insure that the water entering the lake is as clean as possible, thus it would have a greater capacity to dilute the turbid waters already in the lake. This could be accomplished by creating a series of marshes at the head-end of Lake Ashtabula. The incoming silt would have a chance to settle out in these pools and some of the nutrients could be removed by the marsh vegetation. Further details would have to be studied to determine the most effective design of these impoundments.

Greenbelting the Upper Sheyenne River could also reduce the silt load by allowing bankline vegetation to become stabilized. Greenbelting (preventing the intrusion of cattle or development in the flood plain) can be accomplished through a variety of management practices. Such things as zoning or obtaining limited use easements are more commonly used in developed areas. The Upper Sheyenne would be better suited to fencing or a similar practice. If feedlot runoff and cattle access were controlled, siltation and nutrient problems would likely decrease downstream.

Eleven hatchery rearing ponds and the hatchery building at Baldhill Dam National Fish Hatchery would be eliminated by raising the height of the dam and/or bringing it up to National Safety Standards. During discussions, the Corps has indicated the rearing ponds and hatchery building would be replaced. These would be relocated at either Baldhill Dam or the Valley City National Fish Hatchery. Replacement of ponds must occur at the same time or prior to conversion of the existing ponds to project purposes. This will insure that hatchery commitments for fish are met. Further coordination with the Bismarck Area Office will be required prior to construction with regard to location and design criteria.

The building at Baldhill Dam National Fish Hatchery is essential for the efficient operation of the hatchery. Construction of a new building should likewise occur at the same time or prior to razing the old one.

Terrestrial Resources. There are 1,214 acres of existing wildlife habitat that will be affected in varying degrees by a 5-foot raise in the flood pool elevation of Lake Ashtabula (Table 5). There are two approaches to mitigating habitat losses associated with the raise of the flood pool elevation. The first would be to mitigate the losses in the flood pool by purchasing wildlife habitat outside of the project lands. Based on the HEP procedures 450 acres of existing habitat (woodland, grassland and shrubland) that would be required for mitigation outside of the reservoir boundaries (potential areas suitable for mitigation have previously been provided to the Corps). The 450 acres was developed by calculating an Average Annual Loss in habitat units and dividing this by the wildlife management potential of the existing habitat (see EVALUATION METHODOLOGY, page 5). This yielded the mitigation requirements in acres. Habitat replacement should occur at the same ratio as the losses.

A second approach is to maximize wildlife management on project lands, and thereby reduce mitigation requirements (the purchase of separable wildlife lands) as much as possible. Through the HEP process, the amount of mitigation needed if an intensive wildlife management plan were instituted on project lands was calculated. Since a firm takeline and the inclusive acreage is not known at this time, we assumed that all project lands (approximately 1,214 acres), to elevation 1271 msl, would be used for wildlife purposes. All habitat types except hardwoods can be replaced on project lands. An additional 238 acres of woodlands would either have to be purchased outside of the project lands or approximately 238 acres of tree plantings could be carried out on project lands. There is an excess amount of tame grassland habitat on the project lands that could be used for this purpose. The excess grassland acreage is roughly equivalent to the acreage needed for tree planting. Management of the project lands would require the restoration of the habitat to a more

Table 5: Compensation acreage needed to offset losses caused by a 5-foot raise in Lake Ashtabula.

Habitat Type	Total Acres of Habitat Available	H.S.I. Value	Habitat Units	Average Ann. Equiv. Loss in HU's	Average Ann. Equiv. Loss in Acres	Mgmt. Potential Outside Flood Pool	Total Acres of Mitigation Needed*
Hardwoods	170	.60	102	73	122	.25	292
Grassland	474	.36	171	68	189	.44	155
Shrublands	7	.61	4	1	2	.29	3
Wetlands	563	.54	304	0	---	.36	---
TOTAL	1,214			142	313		450

*Approach No. 1 - Purchase 450 acres of existing habitat and manage for wildlife. These lands could be acquired anywhere in the Sheyenne Basin.

optimal condition for wildlife. If all grassland and hardwood losses are replaced through management of existing lands, and there is grassland and shrubland habitat remaining within the project takeline, there may be an opportunity for some enhancement. This assumes that a specific wildlife management program would be carried out on project lands. At this time, no formal management plan has been developed. Also, no defined project boundary other than the existing one has been evaluated.

Planting shelterbelts in selected locations could be part of a wildlife management plan. This may not be an equal exchange for woodlands lost because of the different tree species involved, but would still provide many of the woodland values for wildlife, such as providing shelter from winter storms.

Because the habitat is of lower quality and small acreages are involved, this type of replacement is acceptable. Project lands could be improved with fencing and management. Even though the project lands form a fairly narrow band around the reservoir, they could be valuable to wildlife. Thus, fencing should be included as a mitigation cost.

RECOMMENDATIONS

1. If fish rearing ponds at Baldhill Dam are impacted for project purposes, replacement will occur at an equal rate at either the Baldhill Dam or Valley City Hatcheries. Cost estimate for replacement of 11 ponds is =

*Cost of lands 30 acres @ $775/acre =	$23,250
Cost of concrete catch basins @ $8,000/basin =	88,000
Cost of piping & related control structures =	88,000
**Cost of asphalt liners =	61,100
Cost of earthwork @ $4,000/pond =	44,000
Cost of engineering =	30,000
Other contingencies =	50,000
Total	$384,350

*These costs could be highly variable depending on the relocation site.

**Liners may not be needed if a suitable substitute can be found.

2. Hatchery building at Baldhill Dam to be replaced.

Cost of 30' x 50' building =	$100,000
Engineering =	20,000
Cost of piping system =	30,000
Other contingencies =	50,000
Total	$200,000

3. The Corps of Engineers should initiate a study to determine the effectiveness of creating marsh subimpoundments on the upper end of Lake Ashtabula. These marshes would help filter nutrients and trap sediments coming into the reservoir.

4. The Corps of Engineers, in conjunctions with the Soil Conservation Service, ND State Department of Health, ND Game and Fish Department and U.S. Fish and Wildlife Service should develop a plan to control feedlot runoff and cattle access to the upper reaches of the Sheyenne River (greenbelting). The responsible agencies should than implement this plan. Thus, siltation and nutrient problems in the reservoir would be reduced and wildlife habitat improved.

5. A. The Corps of Engineers should purchase 450 acres of existing wildlife habitat of approximately the same habitat value and at the same rate as that being adversely affected by a 5-foot raise. The costs would include the land purchase, fencing and operation and maintenance.

450 acres @ $775/acre =	$350,000
4 miles of fence @ $3,500/mile =	14,000
Total	$364,000

Annual Operation & Maintenance/costs $10/acre/year = $ 4,500

OR

B. If suitable lands are available within the project boundaries, the Corps of Engineers should manage these lands specifically for wildlife purposes. Costs would include fencing and operation and maintenance.

Land costs =	$ 0
Cost of tree planting 238 acres @ $327/acres =	78,000
90 miles of fencing @ $3,500/mile =	315,000
Total	$393,000

Operation and maintenance @ $10/acre/year = $ 8,000/year

6. Project lands, when appropriate, be dedicated to fish and wildlife management purposes and administered under a General Plan in accordance with Sections 3 and 4 of the Fish and Wildlife Coordination Act.

SUMMARY

This comprises the Service's assessment of the Lower Sheyenne River Project. We believe the Selected Plan has merit and should be implemented. While there are some harmful environmental effects, they tend to be minor in nature and compensation could be achieved as described in the "Recommendations".

Any change in project plans or features could substantially alter the effects of the Selected Plan on fish and wildlife resources and other environmental values. If changes do occur after the submission of this Fish and Wildlife Coordination Act Report, we will modify or amend our report as needed.

M. J. Zschomler

" VARIETY IN HUNTING AND FISHING "

NORTH DAKOTA GAME AND FISH DEPARTMENT

2121 LOVETT AVE. BISMARCK, N. DAK. 58505 PHONE 701-224-2180

July 22, 1982

Mr. Gil Key
Area Manager
US Fish and Wildlife Service
1500 Capitol Avenue
PO Box 1897
Bismarck, ND 58501

Re: Lower Sheyenne River
Study - North Dakota

Dear Mr. Key:

The North Dakota Game and Fish Department concurs with the findings of the above referenced report.

Sincerely,

Dale L. Henegar
Commissioner

M:DLH:dk

Dale L. Henegar
COMMISSIONER

Charles H. Schroeder
DEPUTY COMMISSIONER

DATE
ILME